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(54) **ARTICULATION CONTROL SYSTEM FOR ARTICULATABLE SURGICAL INSTRUMENTS**

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(51) **Int. Cl.**

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| ***A61B 17/072*** | (2006.01) |
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| *A61B 17/29* | (2006.01) |

(52) **U.S. Cl.**

CPC ........... ***A61B 17/068*** (2013.01); ***A61B 17/0686*** (2013.01); ***A61B 17/07207*** (2013.01); *A61B 2017/0046* (2013.01); *A61B 2017/00398* (2013.01); *A61B 2017/00477* (2013.01); *A61B 2017/2927* (2013.01)

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USPC .......... 227/175.1, 175.2, 176.1, 180.1, 179.1; 606/139, 142, 153, 219

See application file for complete search history.

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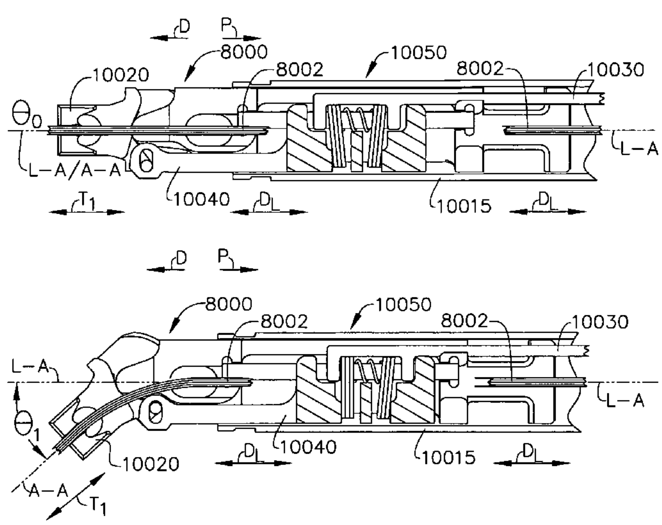
(57) **ABSTRACT**

A surgical instrument comprises an end effector, a shaft, and a housing extending proximally from the shaft. The end effector is movable relative to the shaft between an articulation home state position and an articulated position and comprises a surgical stapler including a plurality of staples and a firing member that fires the plurality of staples. The firing member is movable between a firing home state position and a fired position. The housing includes a motor operably supported by the housing, a controller in communication with the motor, and a home state input configured to transmit a home state input signal to the controller which is configured to activate the motor in response to the home state input signal to effectuate a return of the end effector to the articulation home state position and a return of the firing member to the firing home state position.

**14 Claims, 162 Drawing Sheets**



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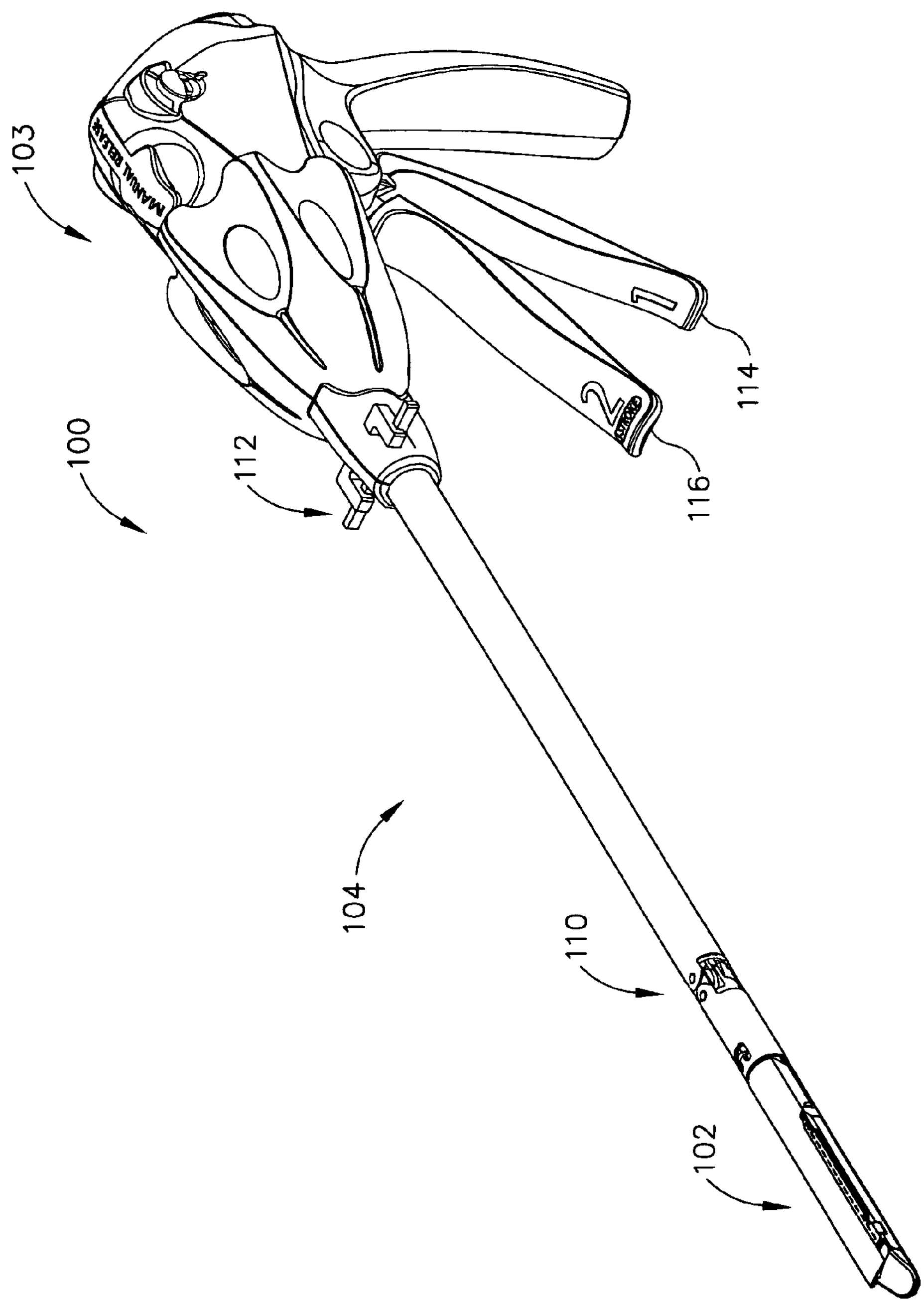


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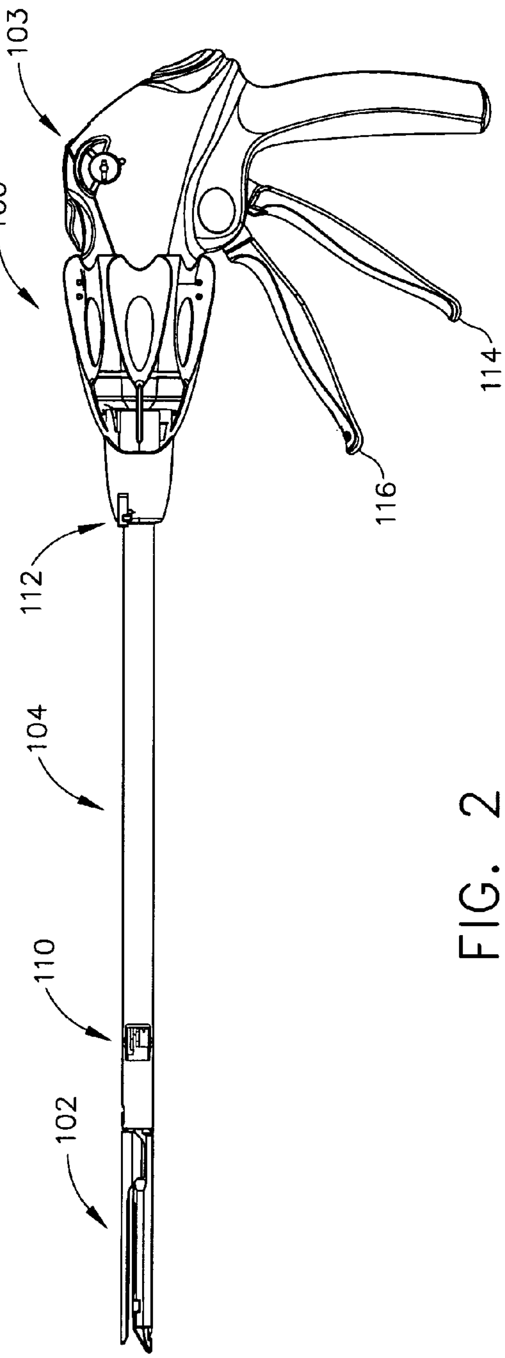
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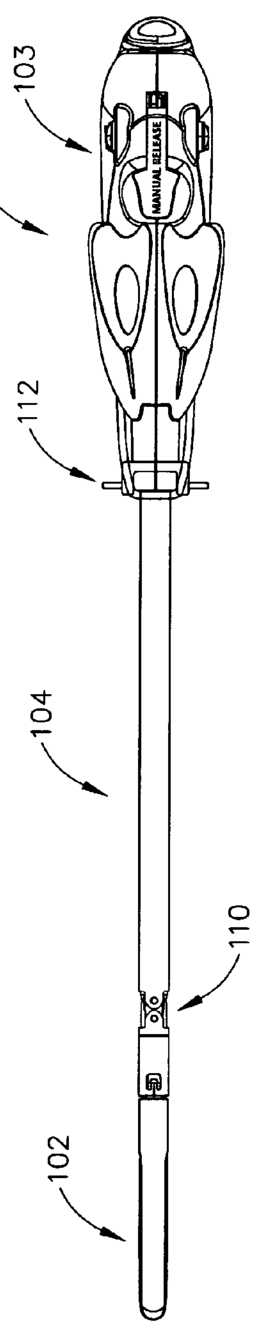
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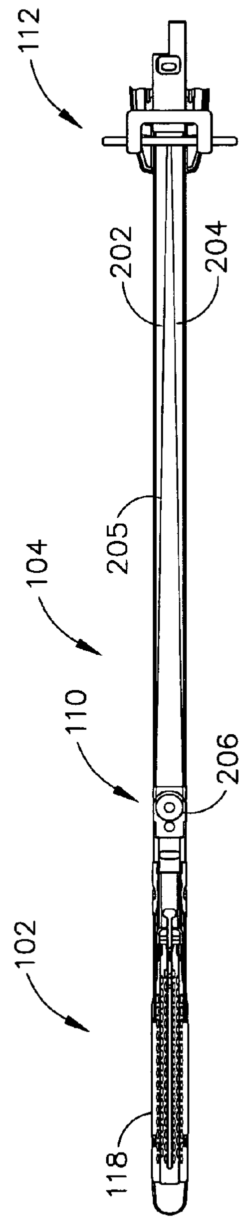

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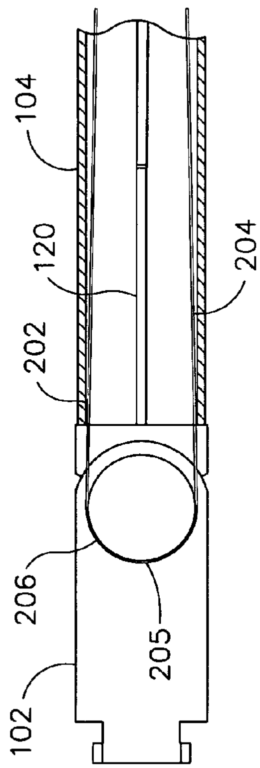

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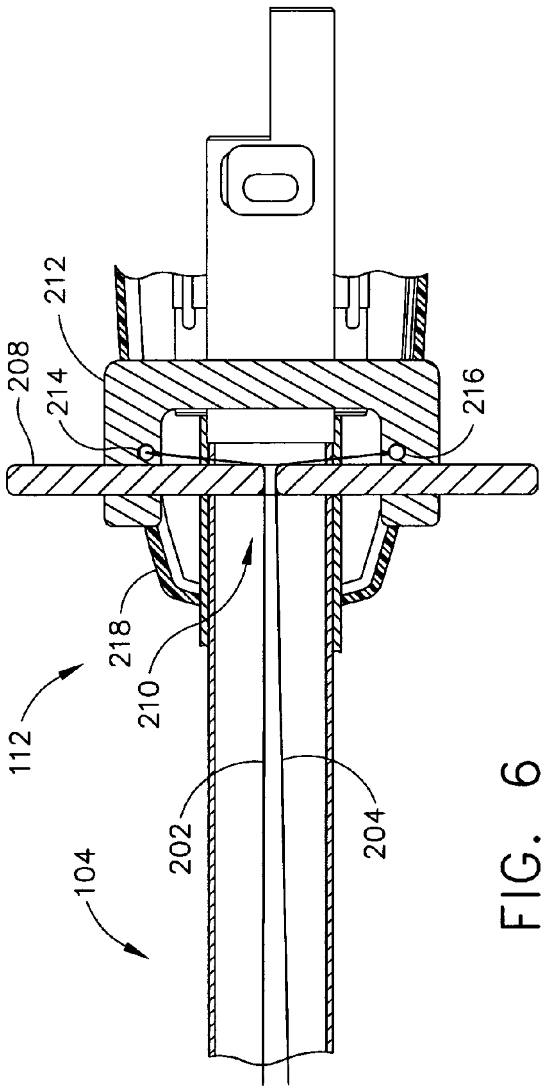
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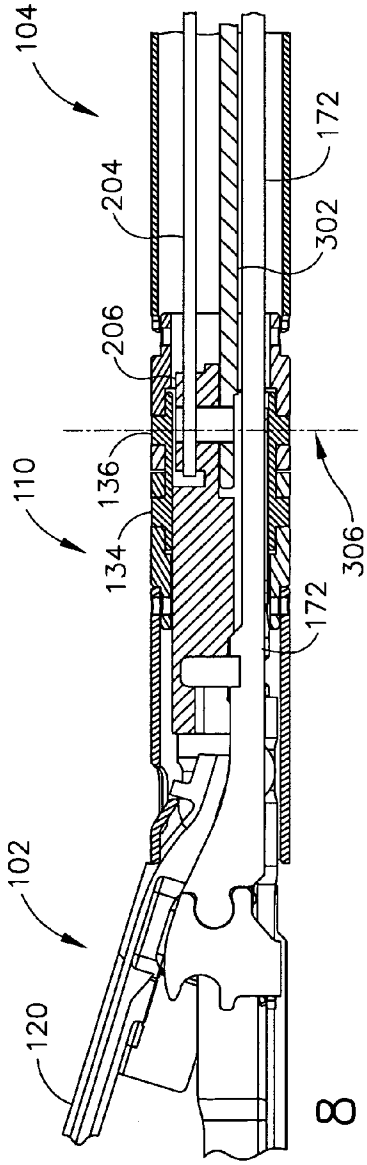
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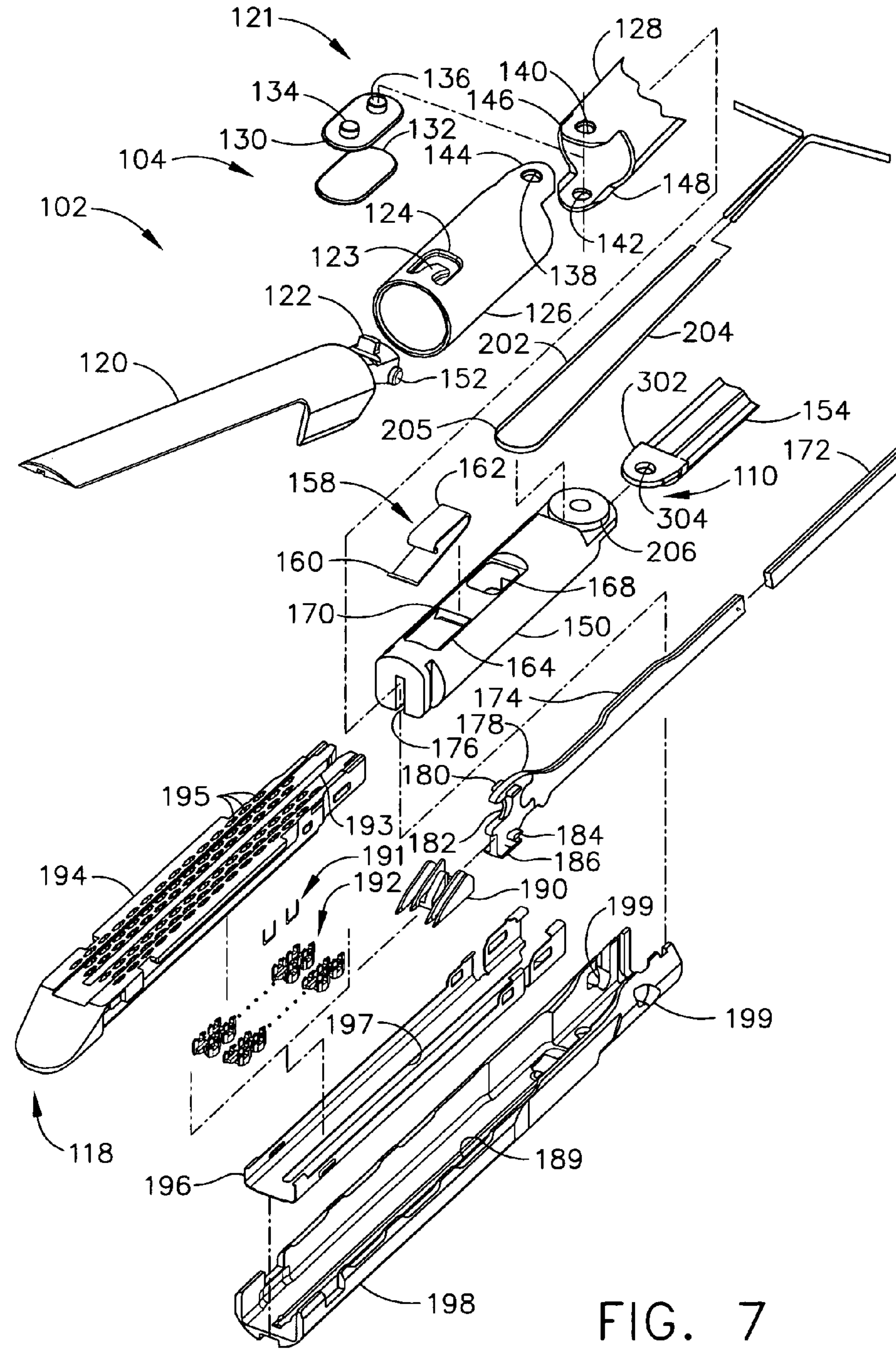
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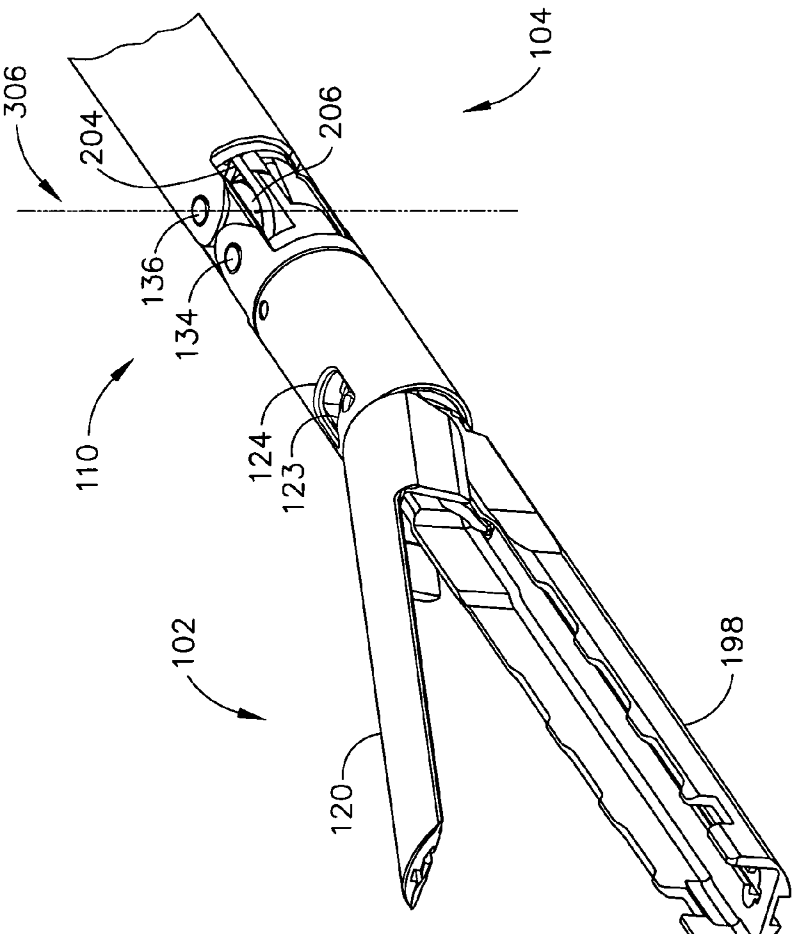
FIG. 7

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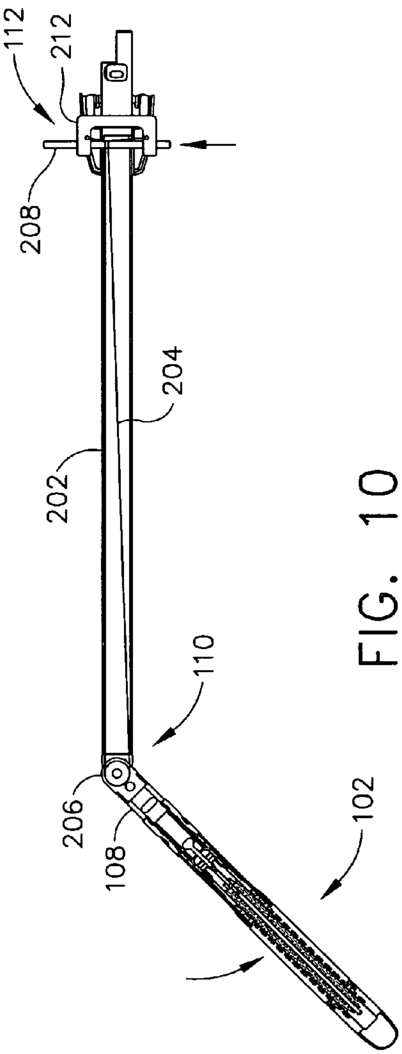
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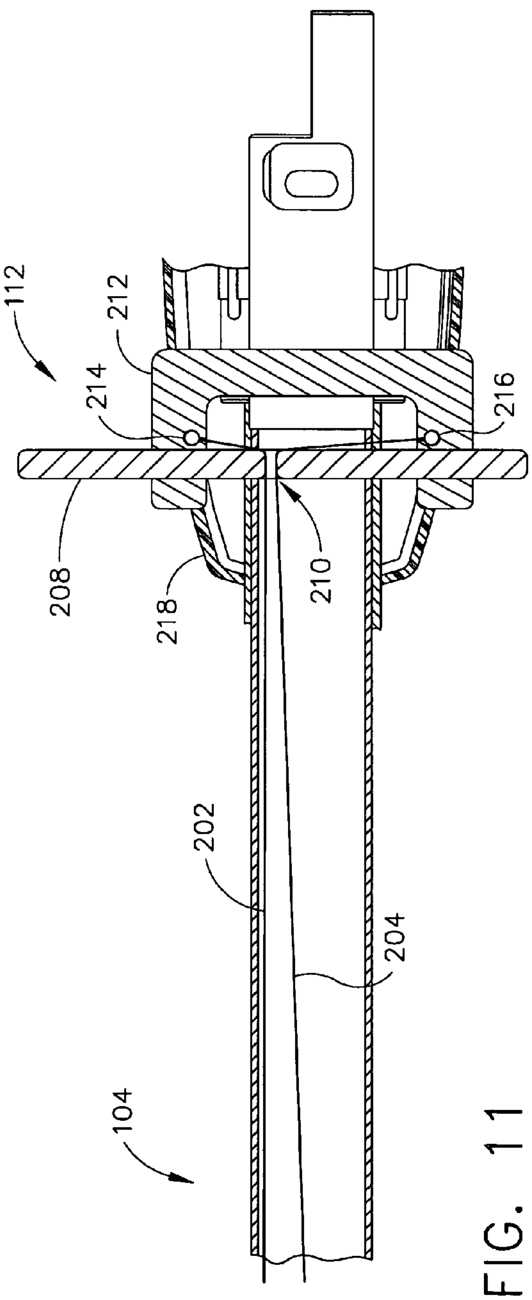
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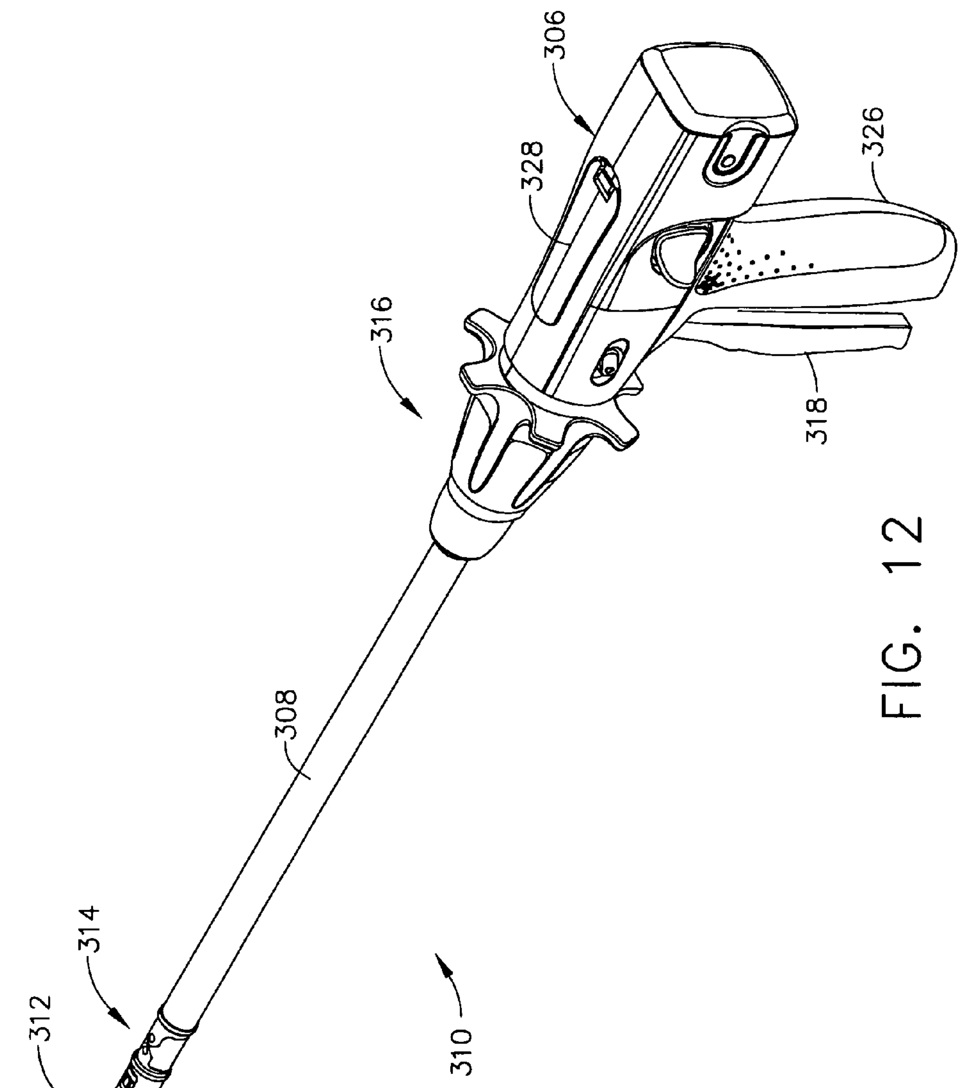


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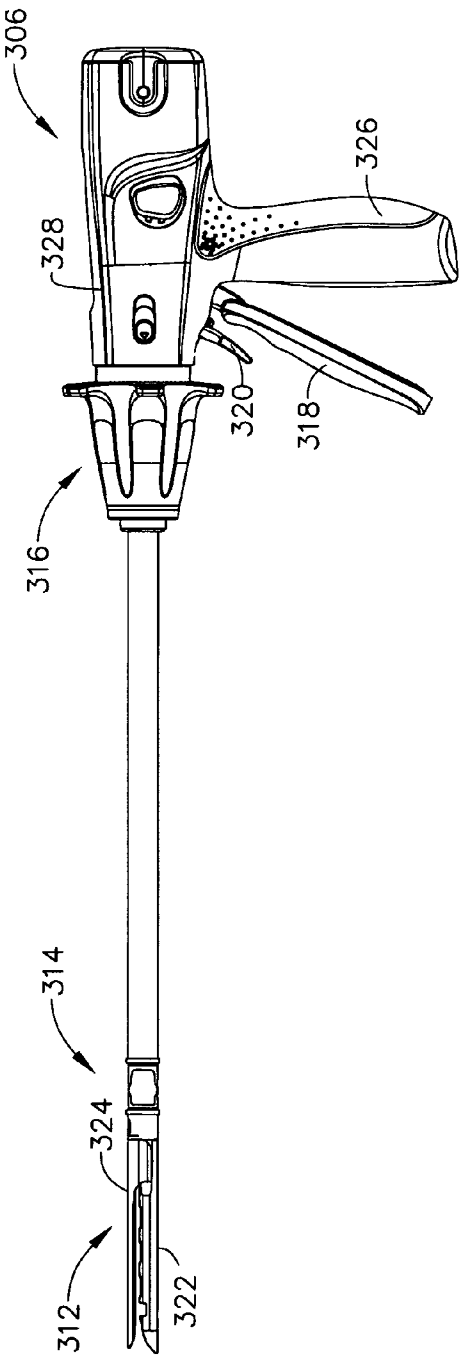


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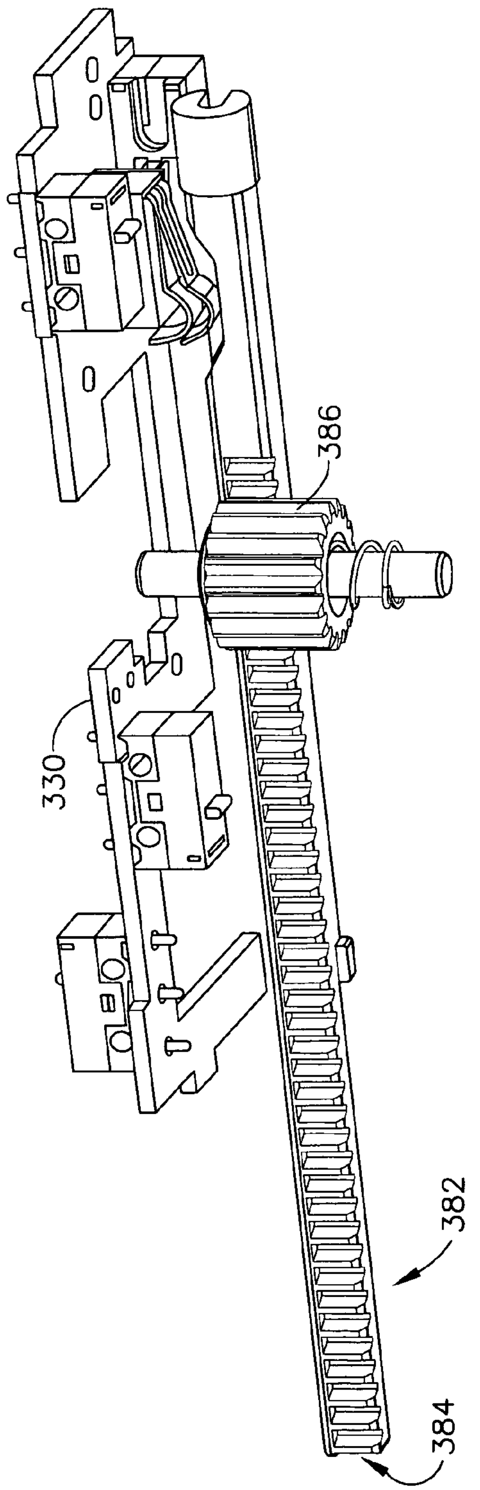


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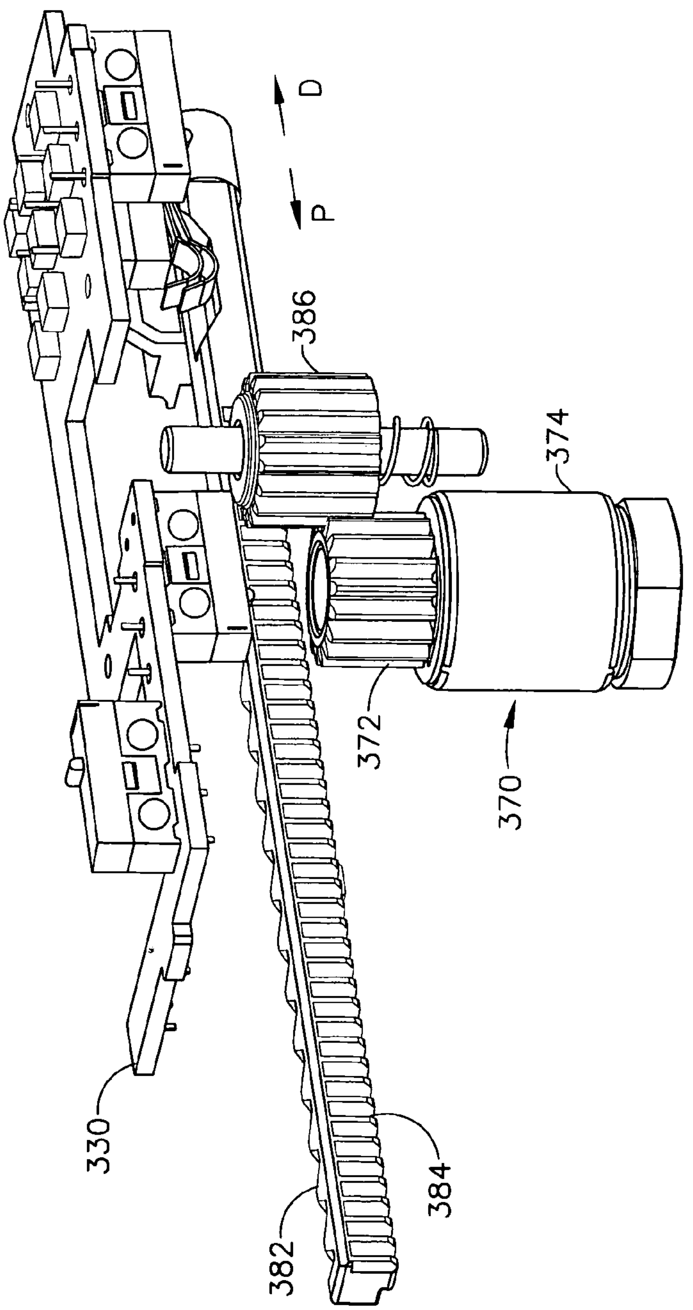


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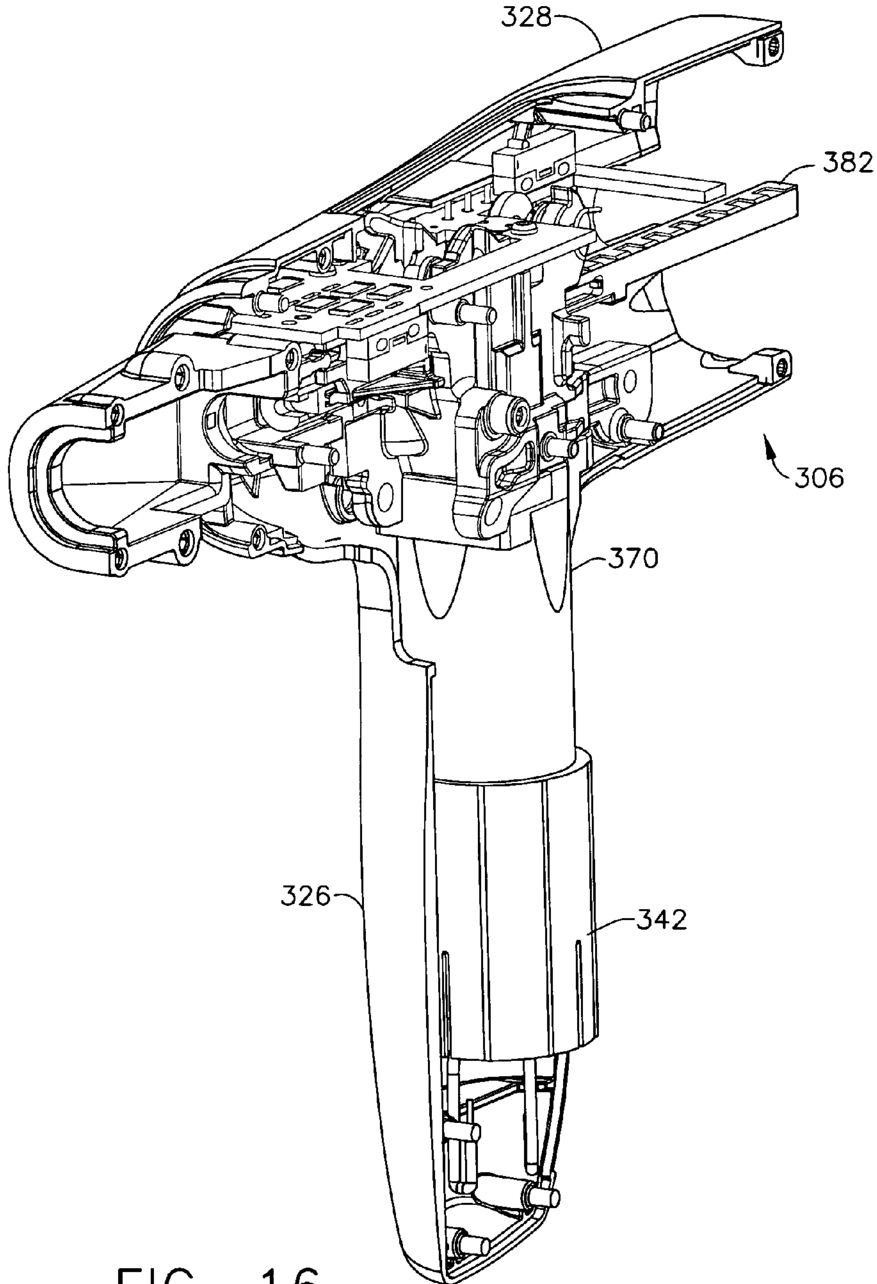


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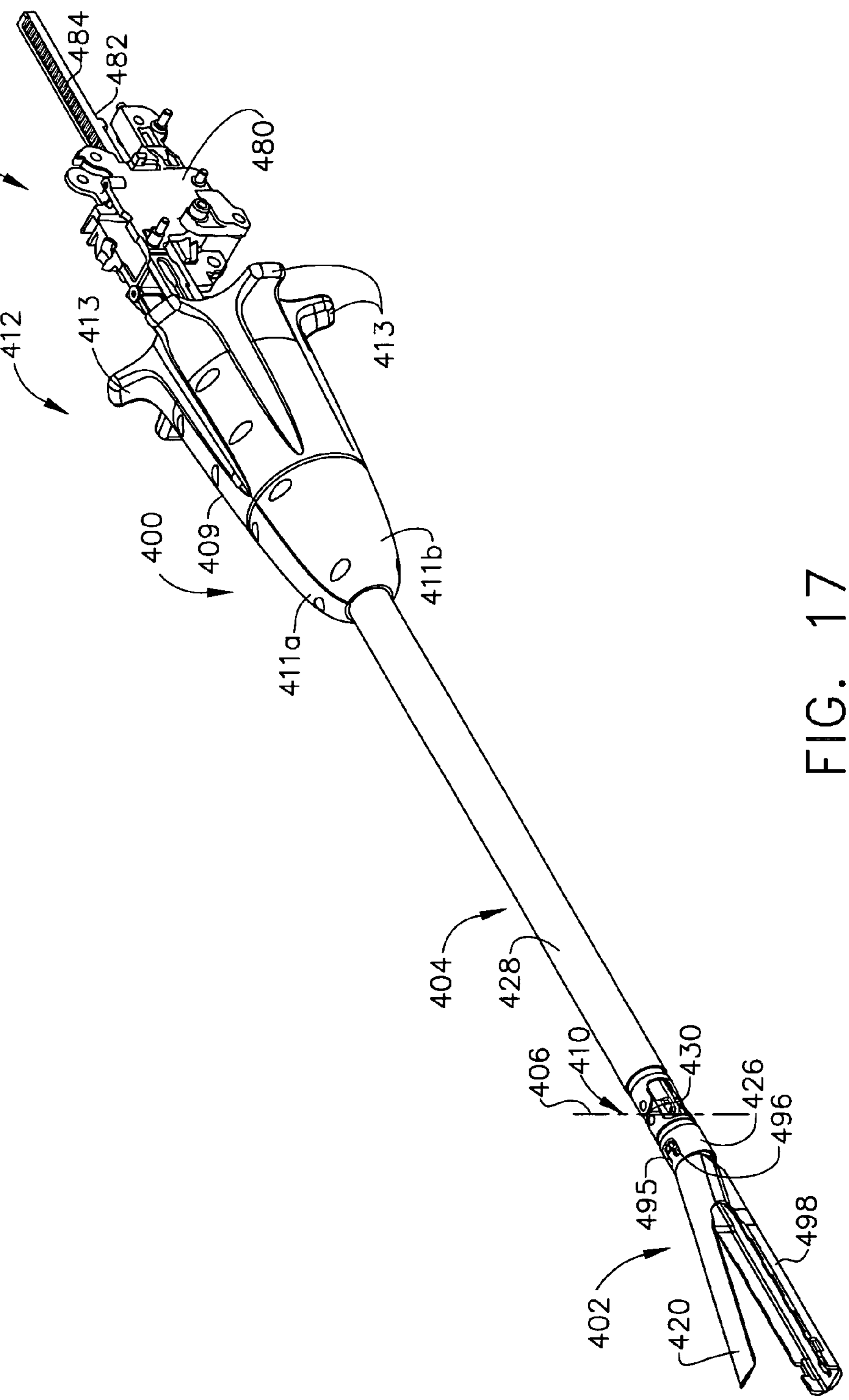
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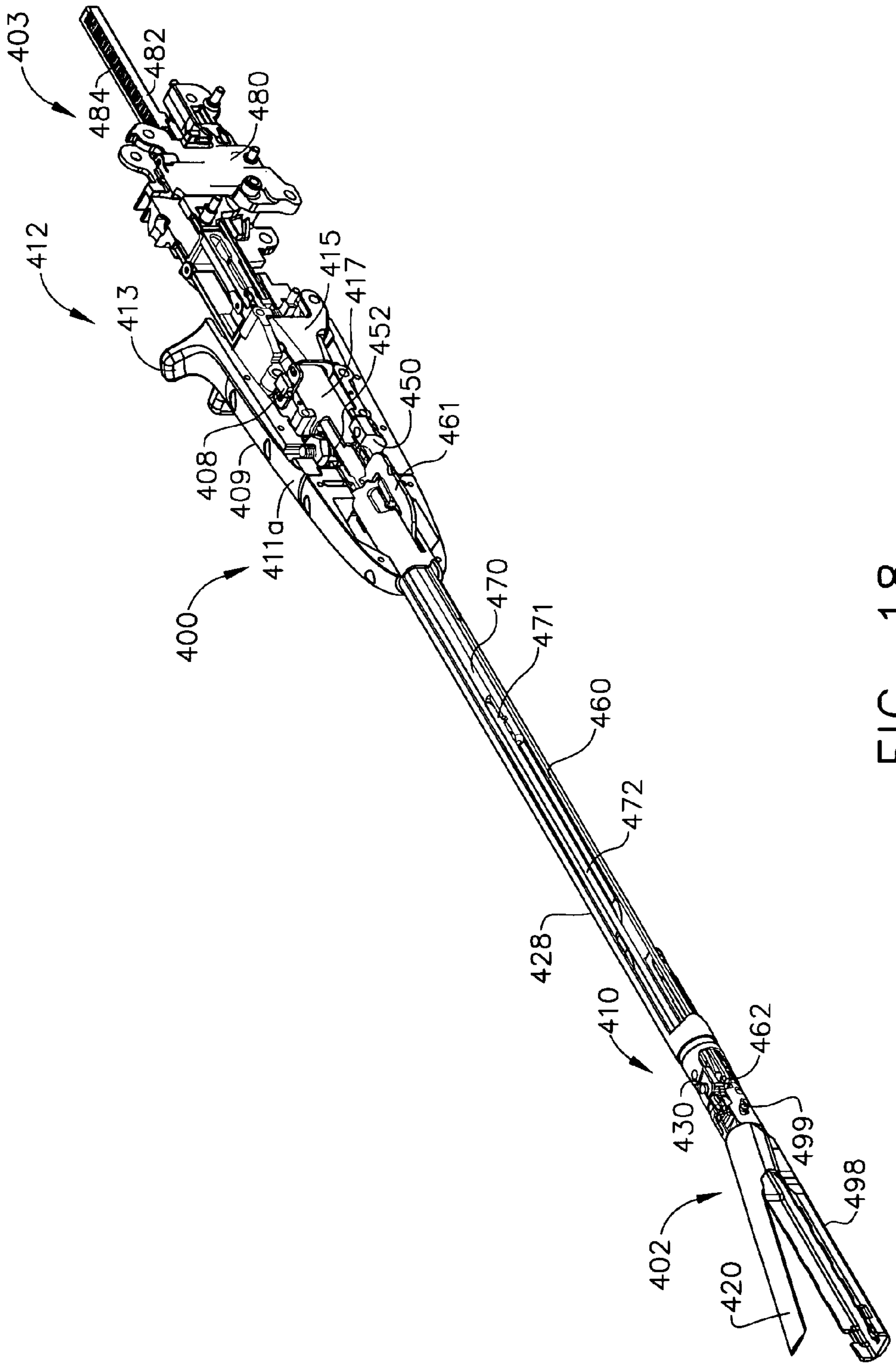
FIG. 17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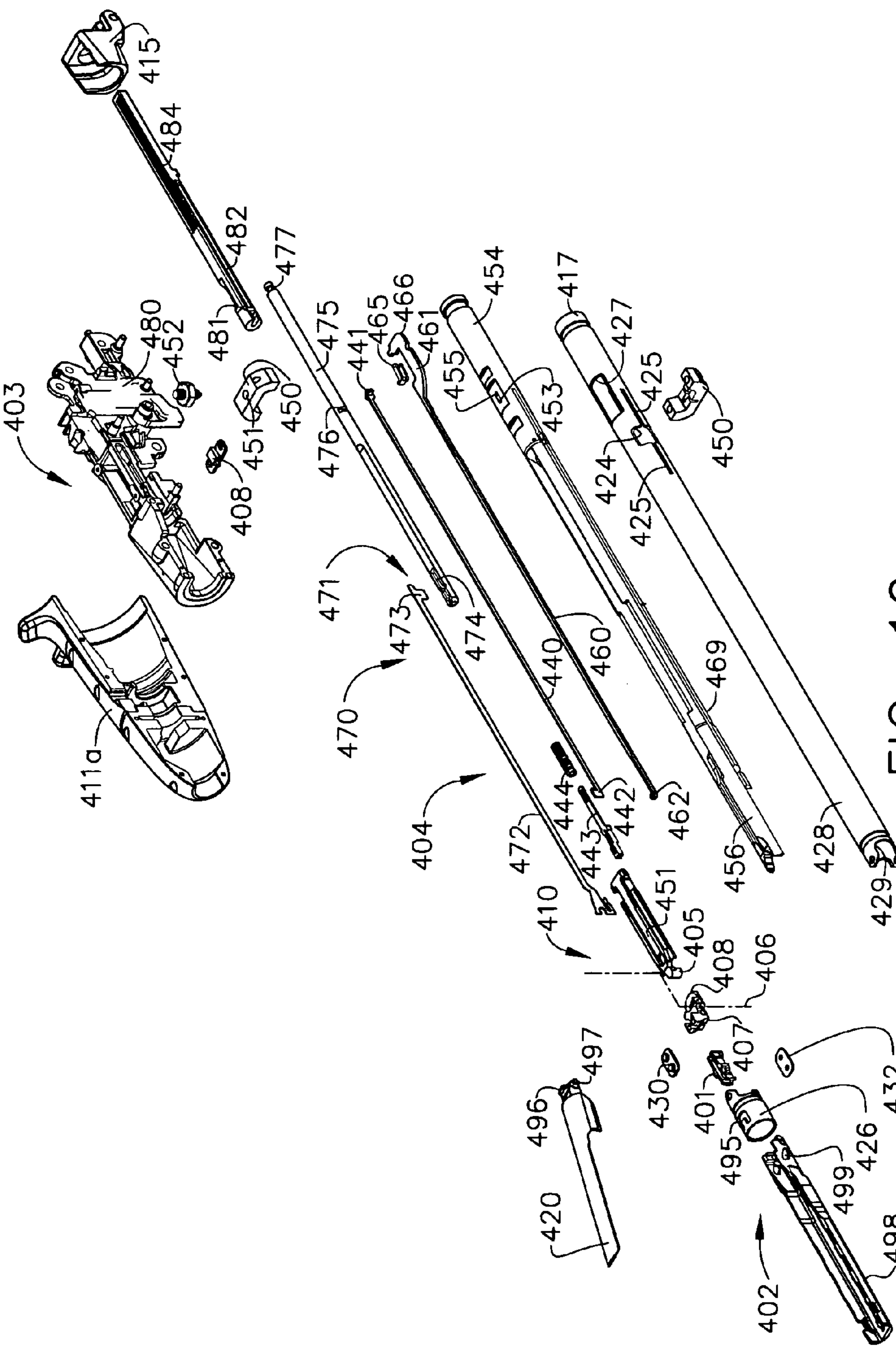
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FIG. 19

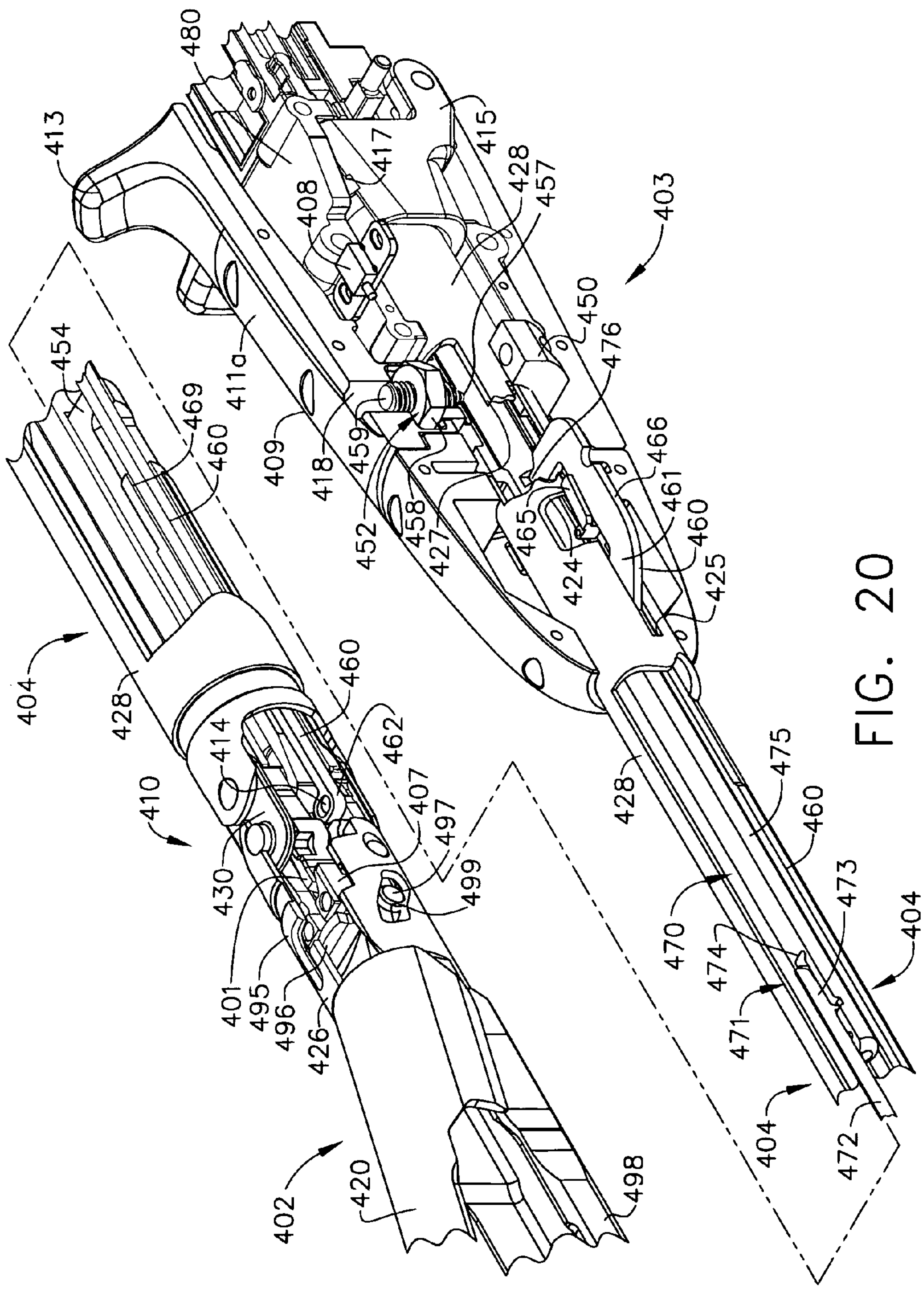
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FIG. 20

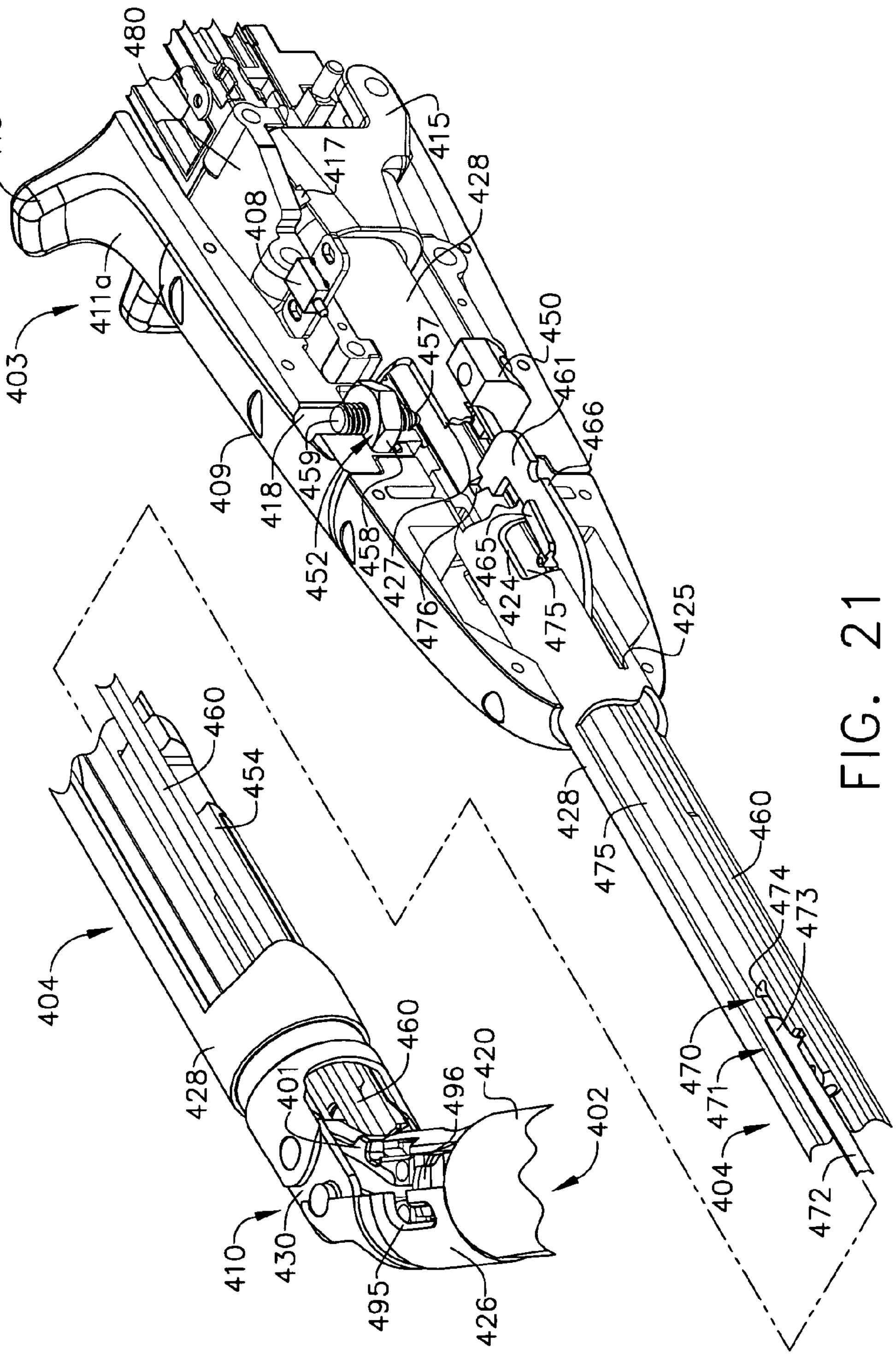
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FIG. 21

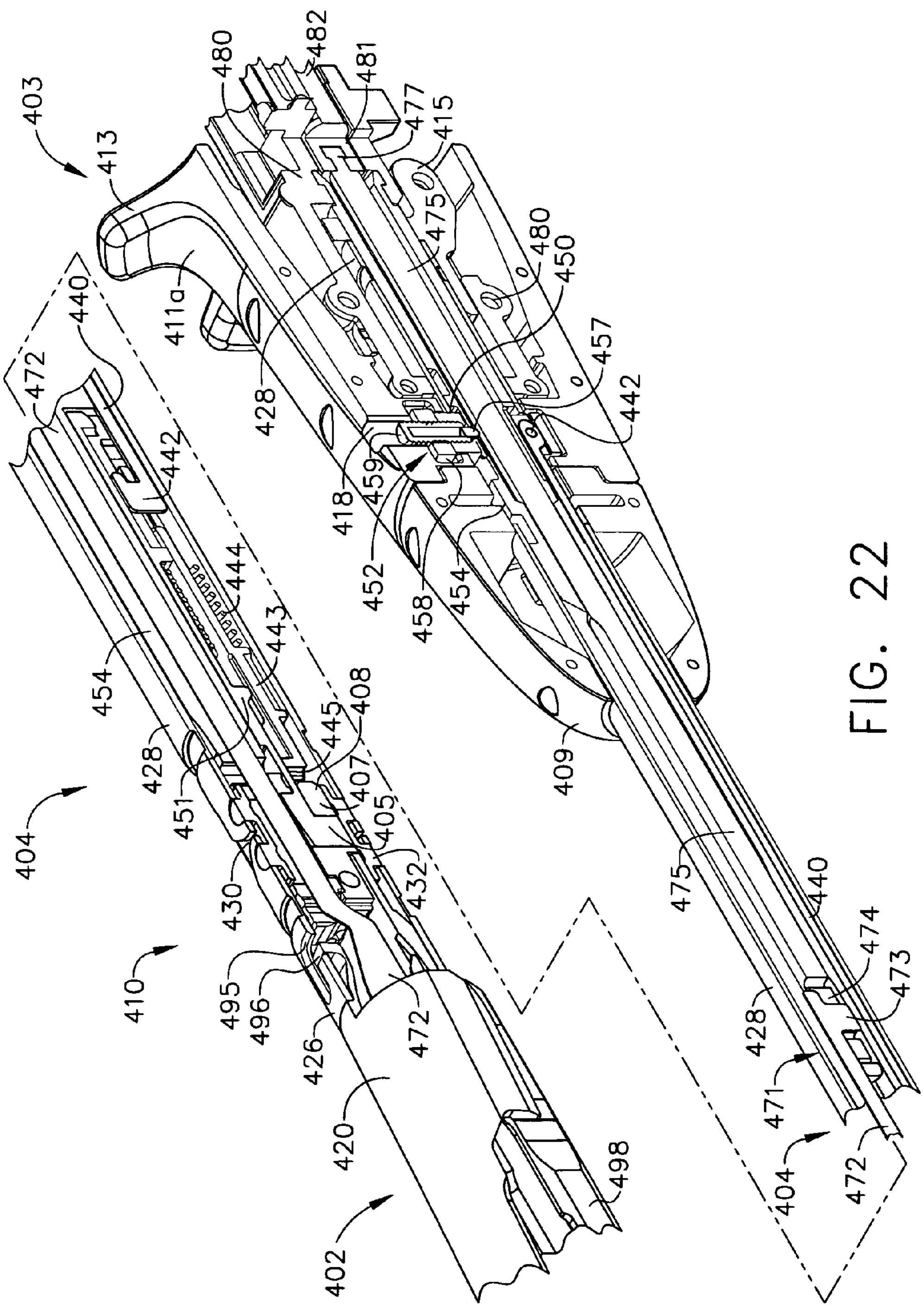
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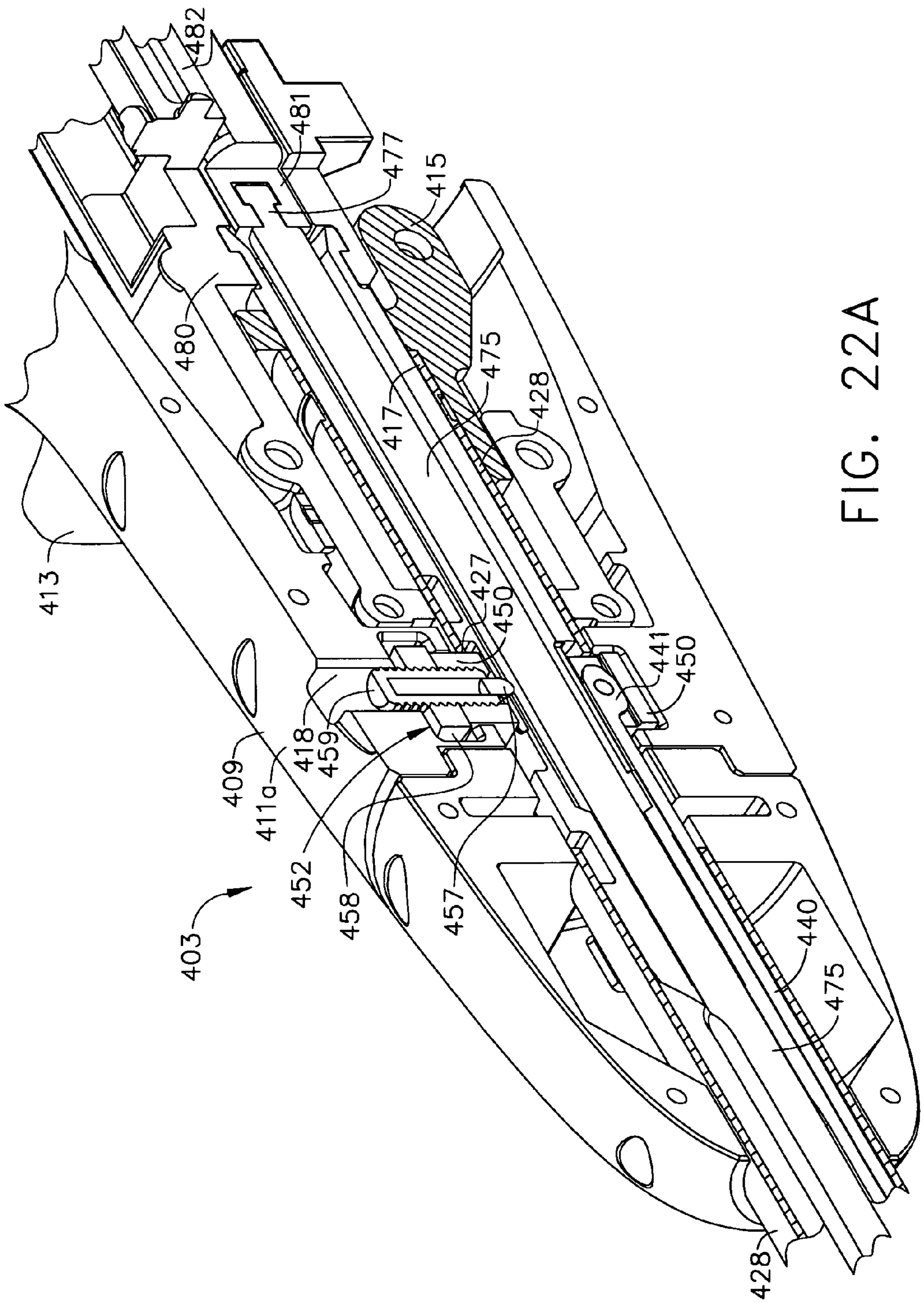
FIG. 22



482
481
477
415
480
475
417
428
413
427
450
441
450
418
459
409
411a
452
458
457
403
440
475
428


FIG. 22A

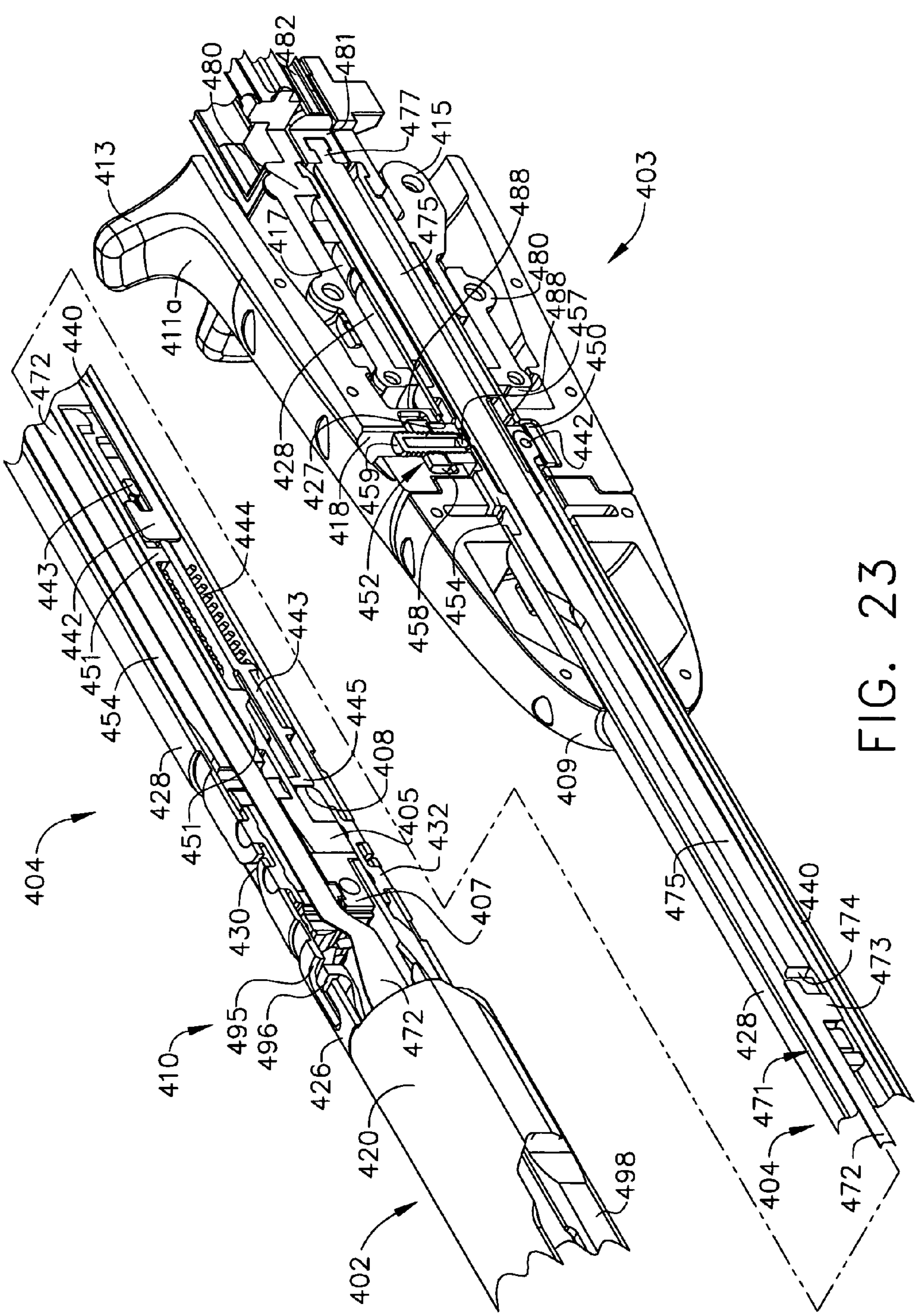


FIG. 23

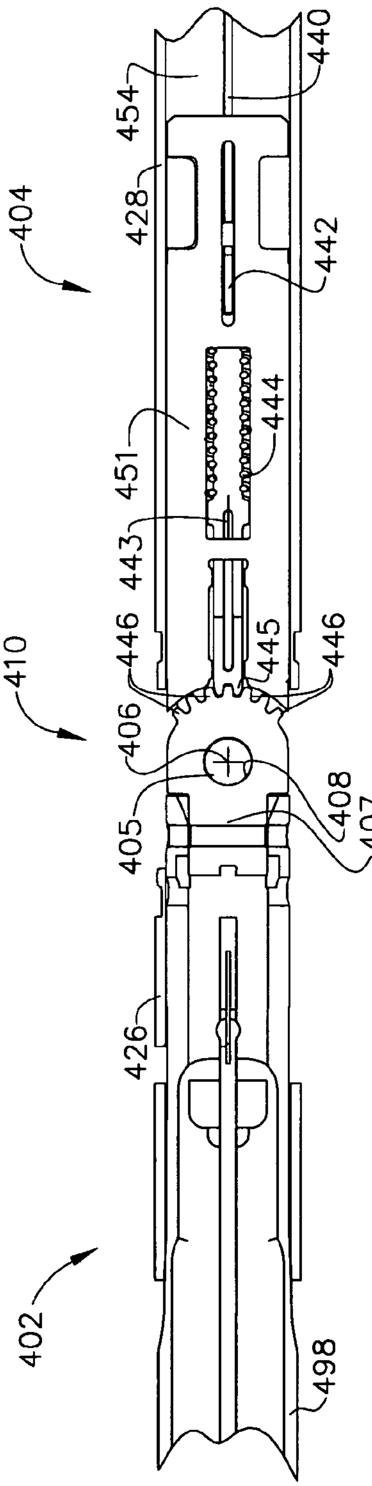



FIG. 24A

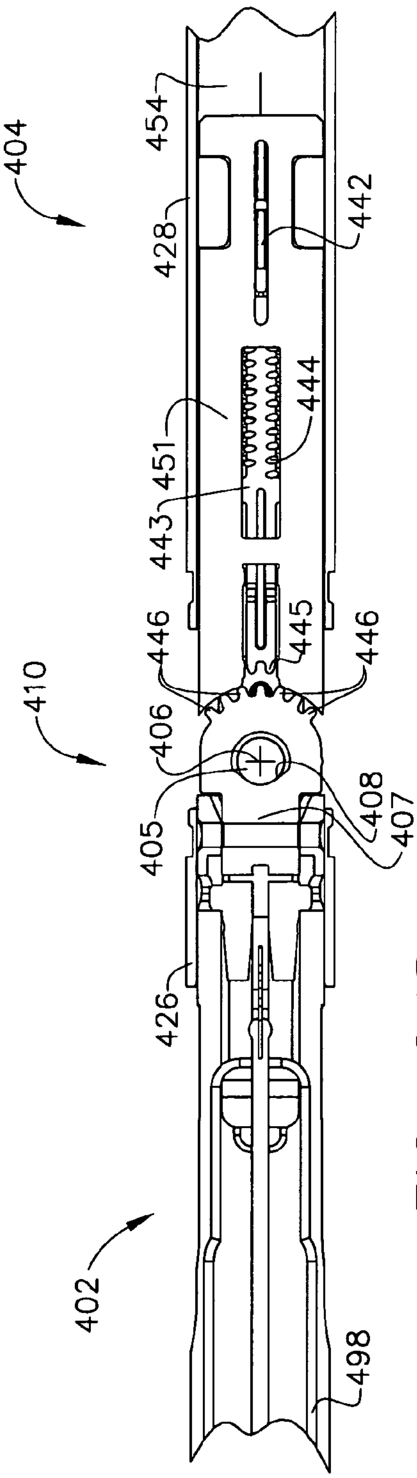



FIG. 24B

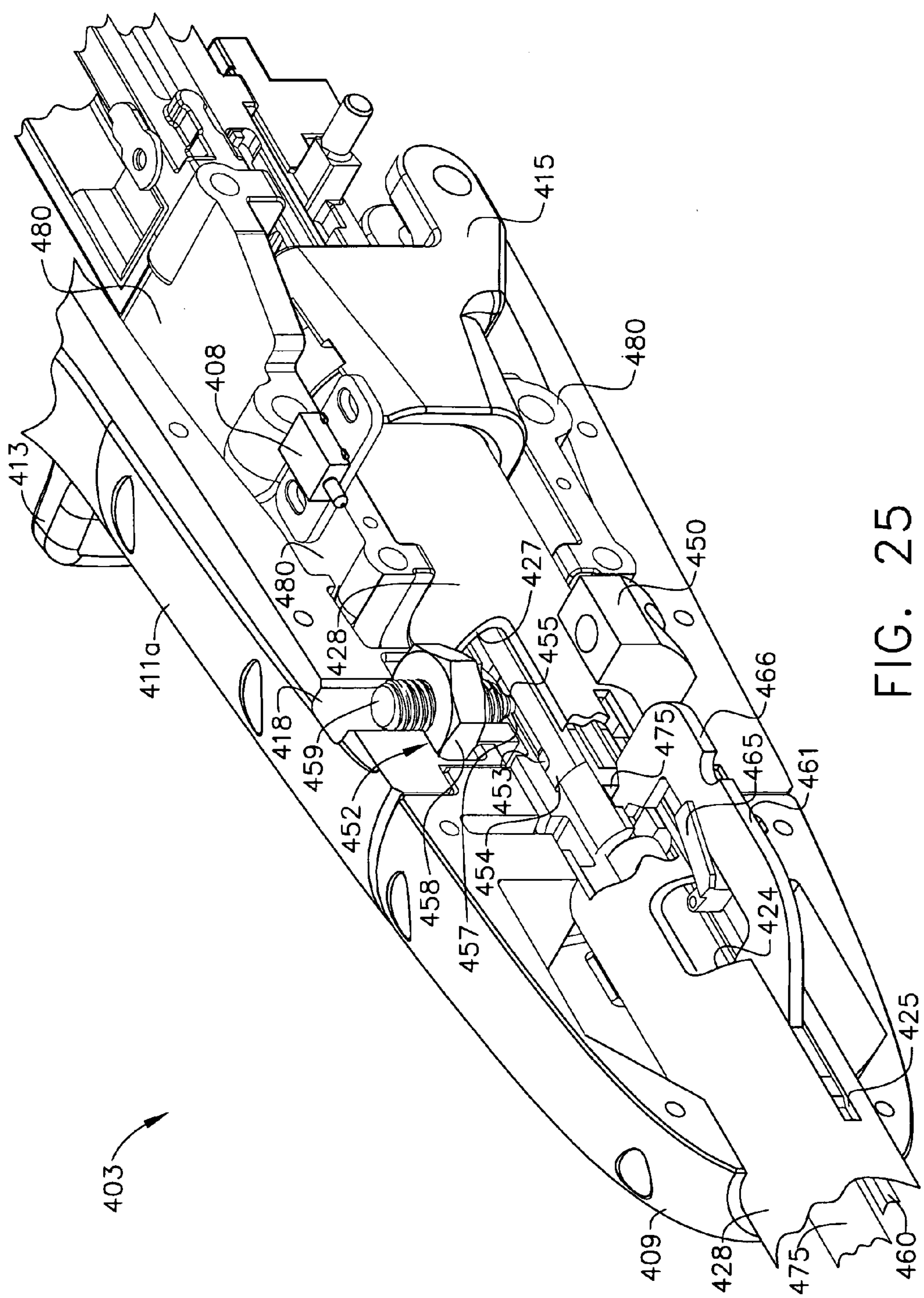

403
409
411a
413
408
480
480
480
415
418
459
452
458
457
454
453
455
427
428
428
450
466
475
465
461
424
425
475
460

FIG. 25

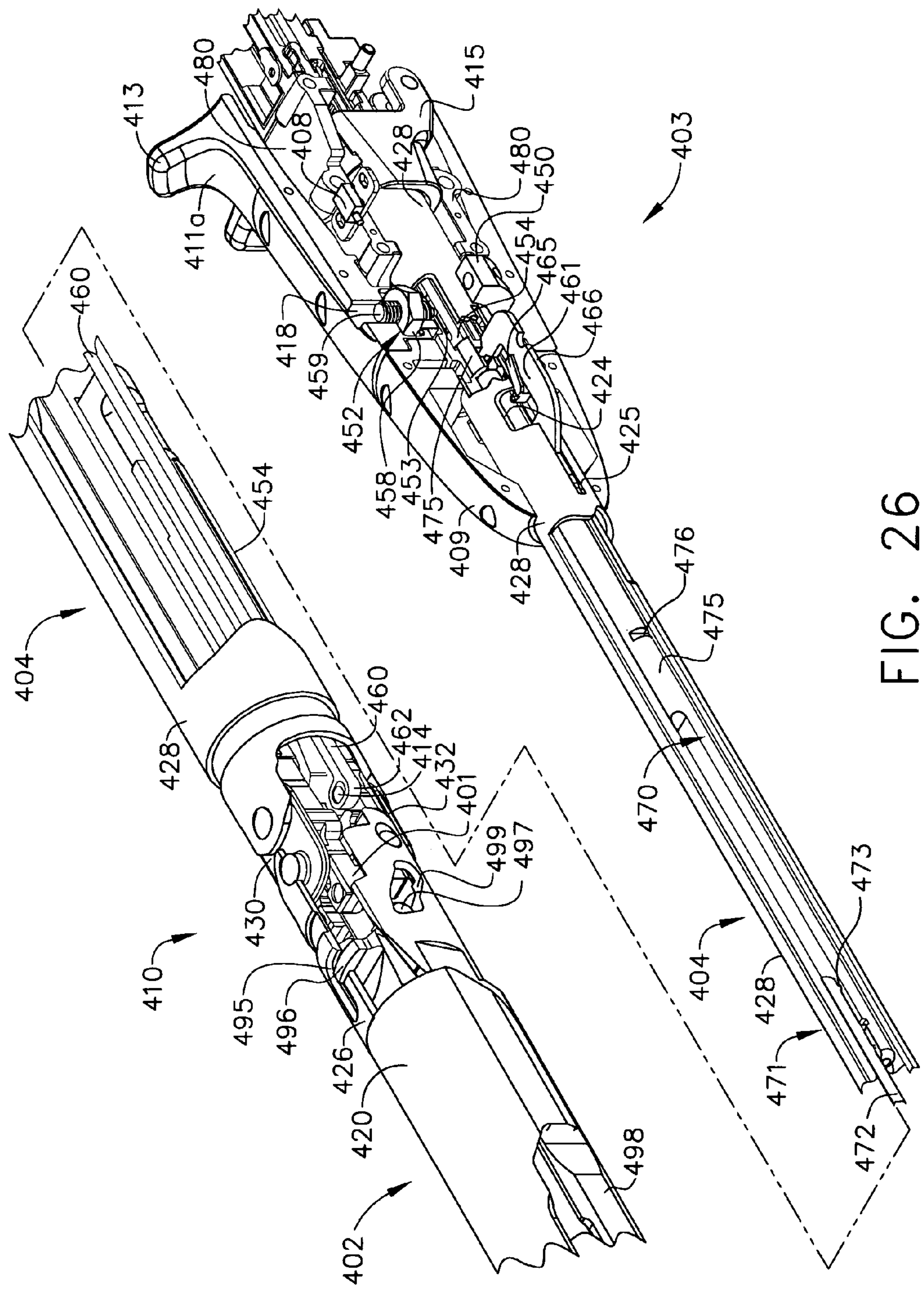

413
480
408
415
428
480
450
403
411a
454
465
461
466
460
418
459
452
424
425
458
453
475
409
428
454
476
475
404
428
460
462
414
432
401
499
497
470
430
410
495
496
426
420
404
428
473
471
472
498
402

FIG. 26

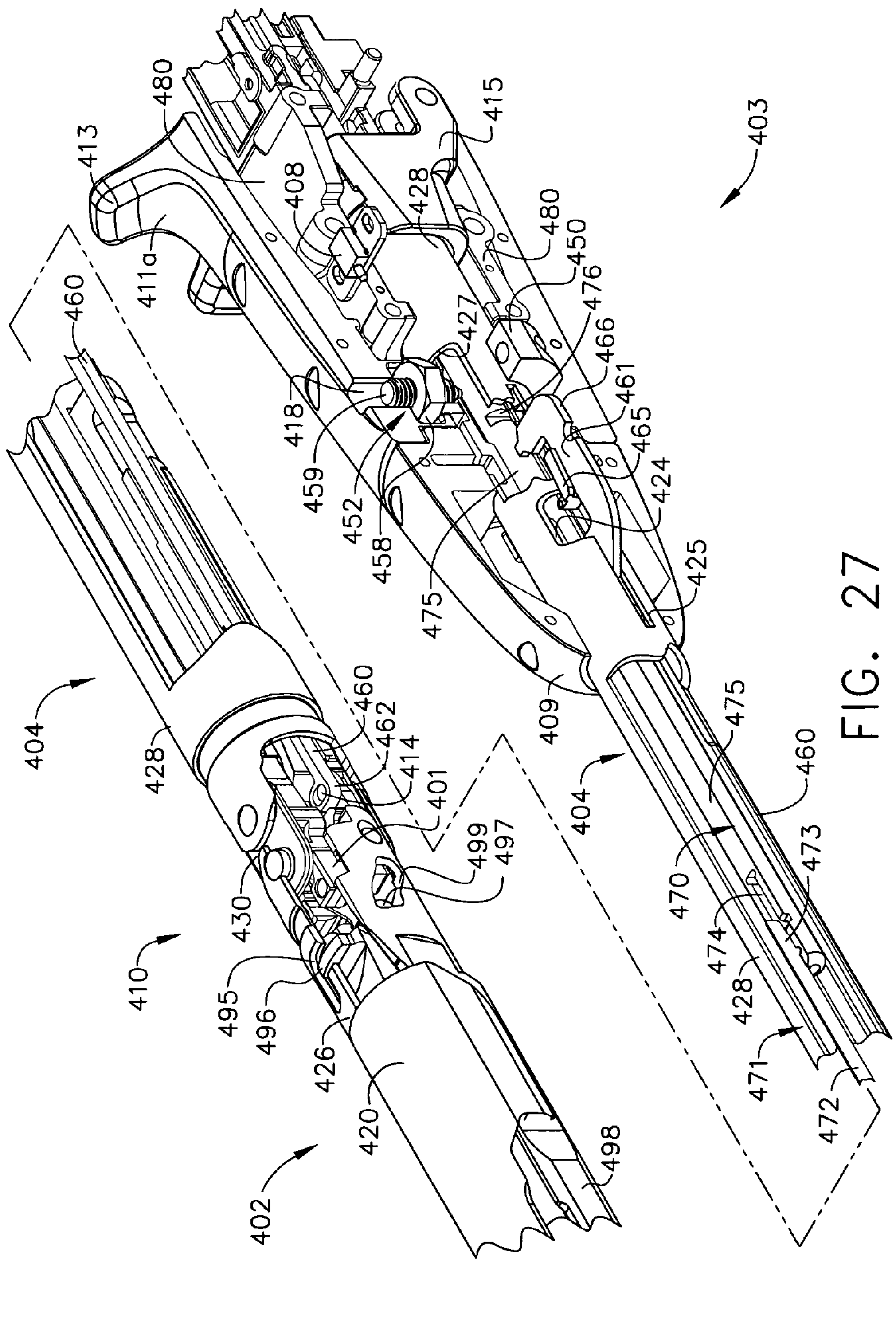
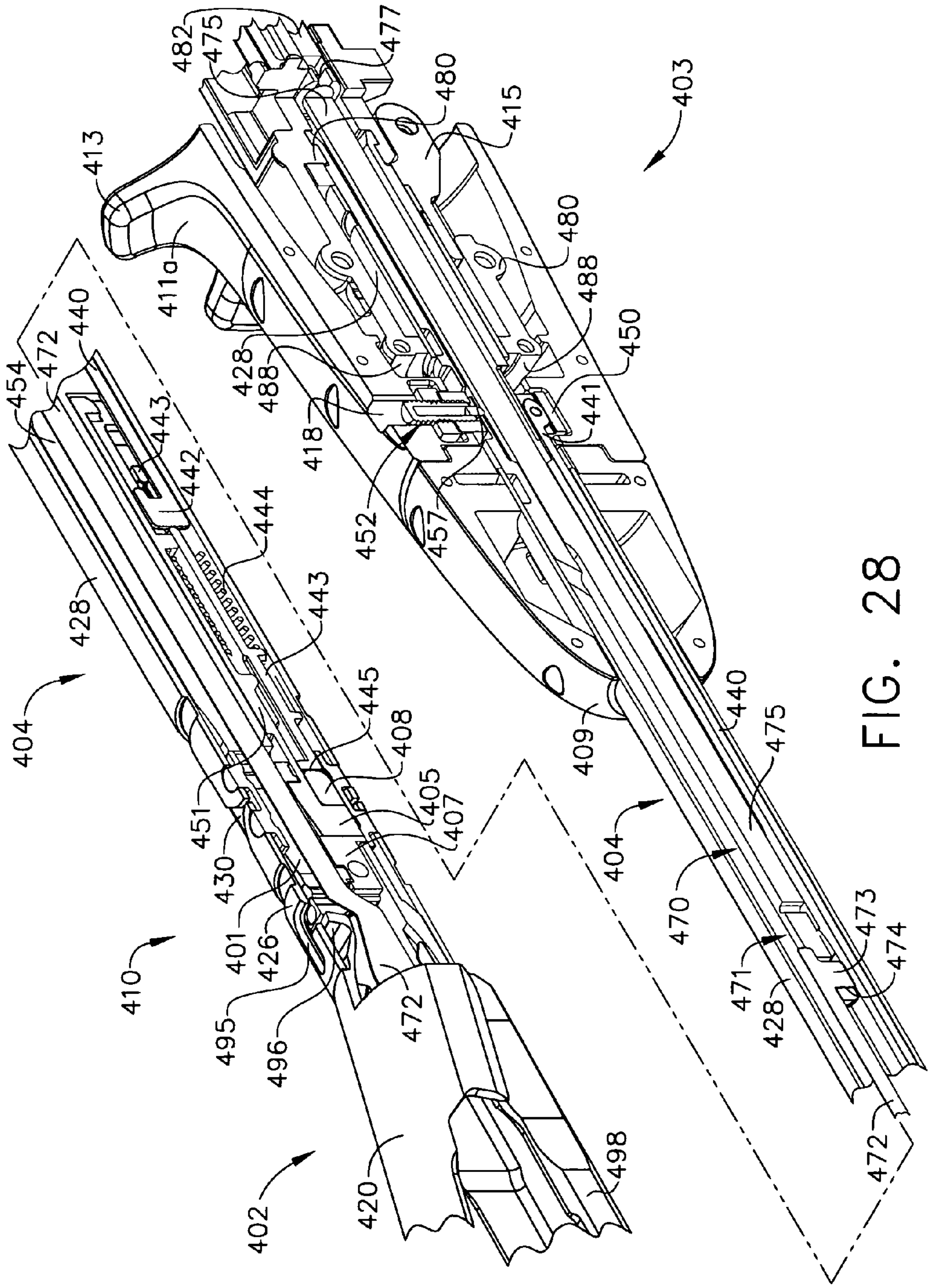

413
480
415
403
408
428
480
450
411a
476
460
427
466
461
418
465
424
459
452
458
425
475
404
409
475
460
428
462
460
414
401
404
499
497
470
473
430
474
410
428
495
496
471
426
472
420
402
498

FIG. 27



482
475
477
480
415
403
413
411a
480
488
450
428
488
441
418
452
457
454
472
440
443
442
444
443
445
428
404
408
405
407
451
430
401
426
410
495
496
472
409
440
475
404
470
471
473
474
428
472
402
420
498


FIG. 28

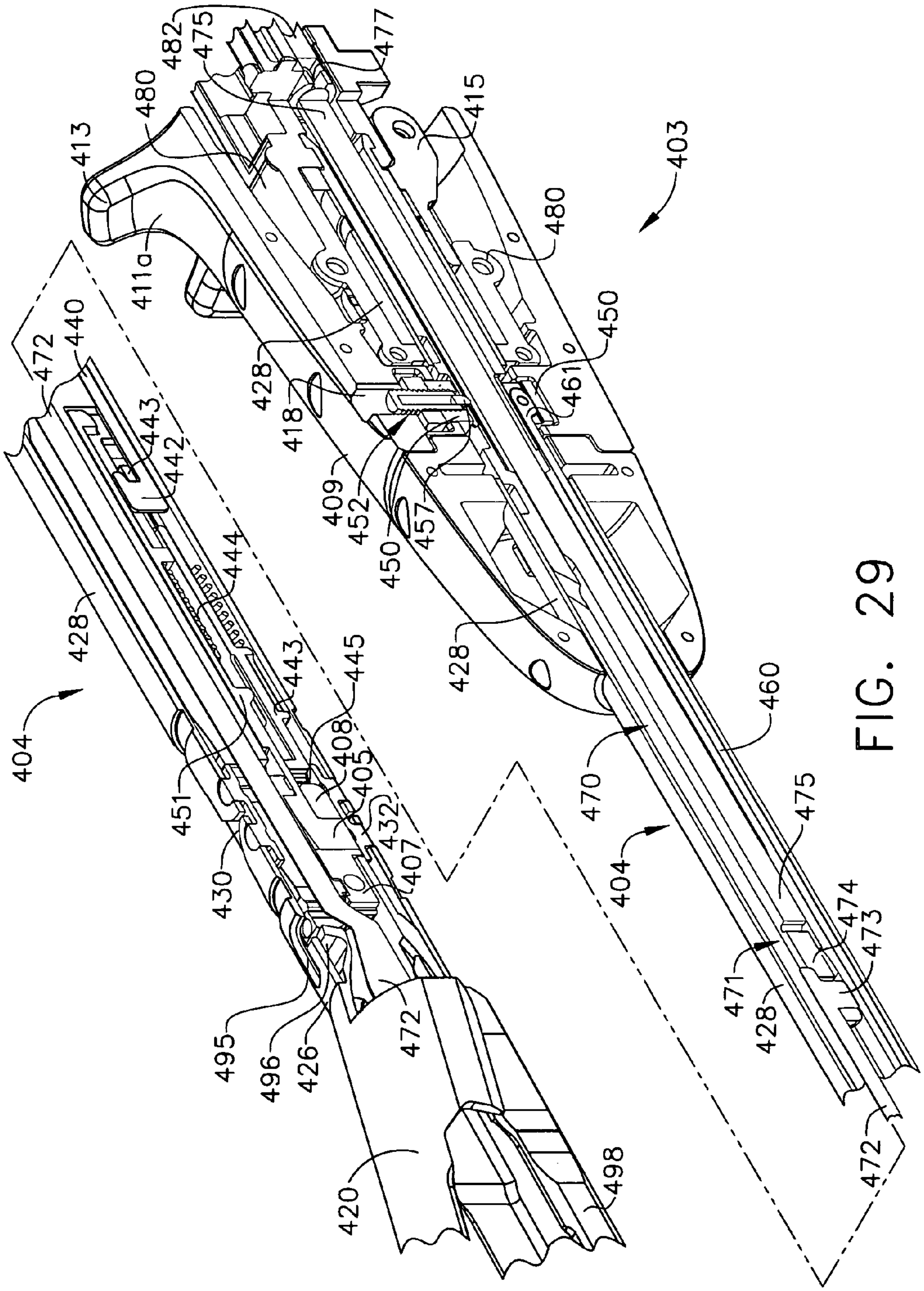

413
480
482
475
477
415
403
411a
480
440
472
428
450
461
443
442
418
409
452
457
450
444
428
460
443
445
404
428
408
405
451
432
470
475
407
430
404
474
473
471
428
495
496
426
472
420
498
472

FIG. 29

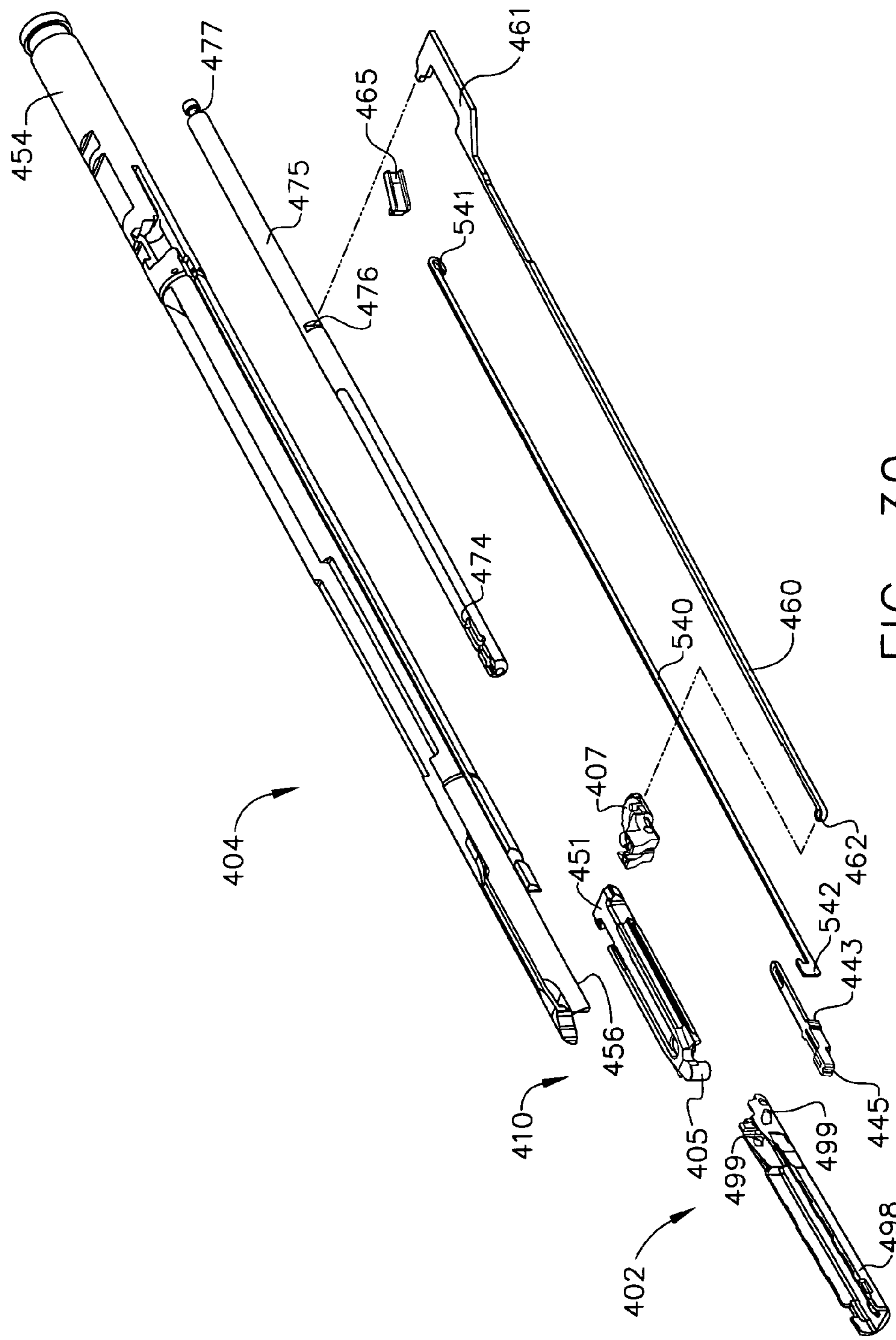

454
477
475
476
465
461
541
474
540
460
407
404
451
462
542
443
456
410
405
445
499
499
498
402

FIG. 30

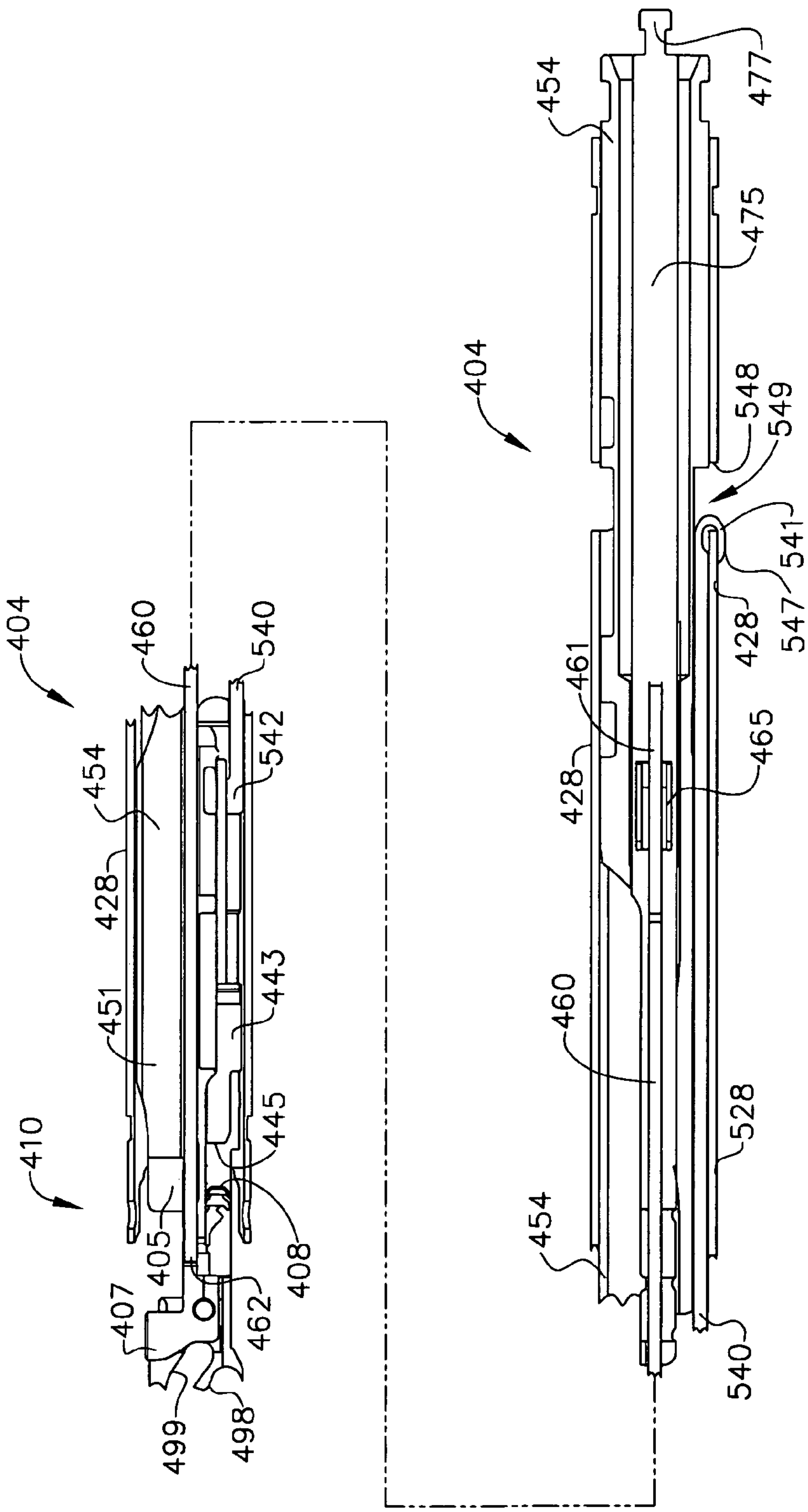
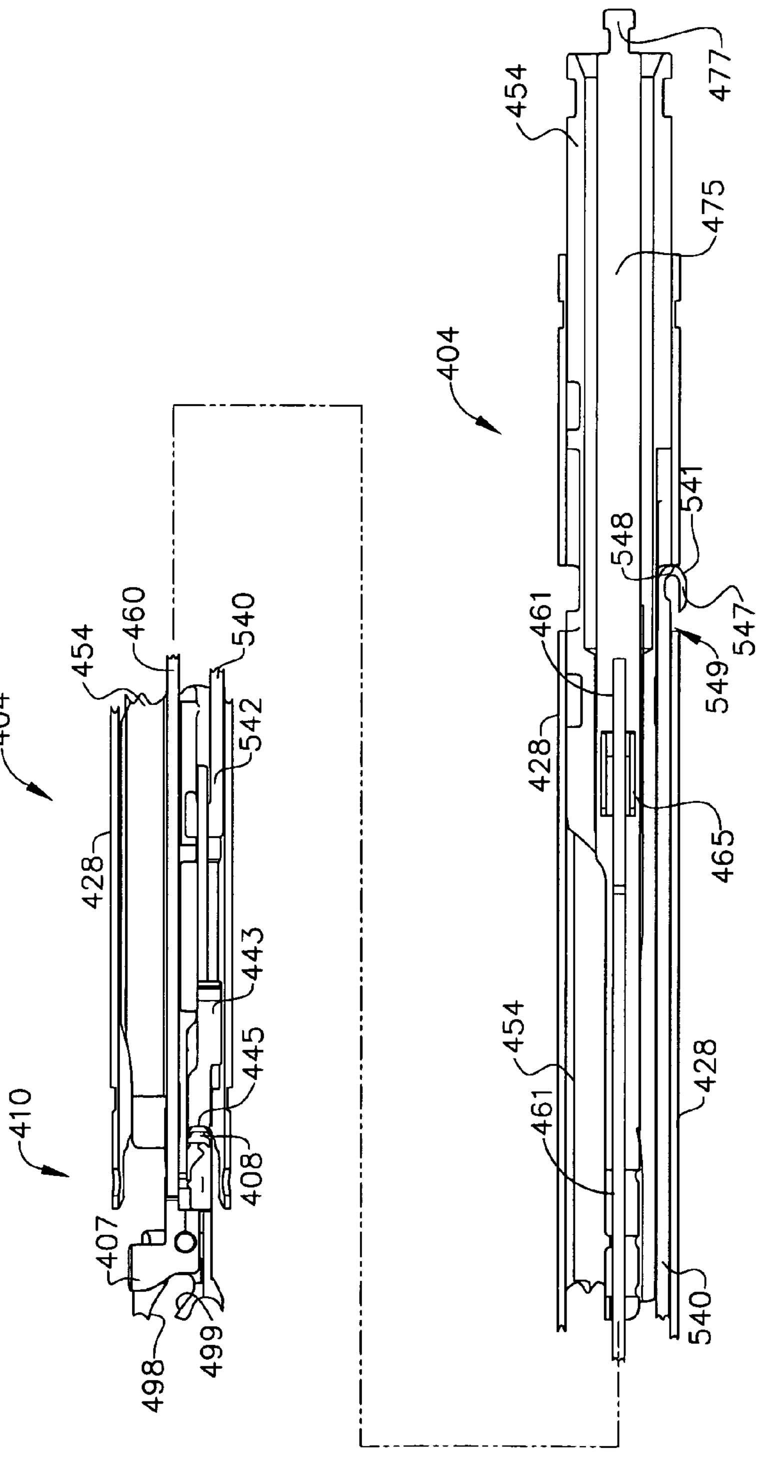

404
460
540
454
542
428
451
443
445
410
405
408
407
462
499
498
477
475
548
549
541
547
461
465
528

FIG. 31



404
410
454
460
540
542
428
443
445
408
407
498
499
477
454
475
404
541
548
547
549
461
428
465
454
461
428
540


FIG. 32

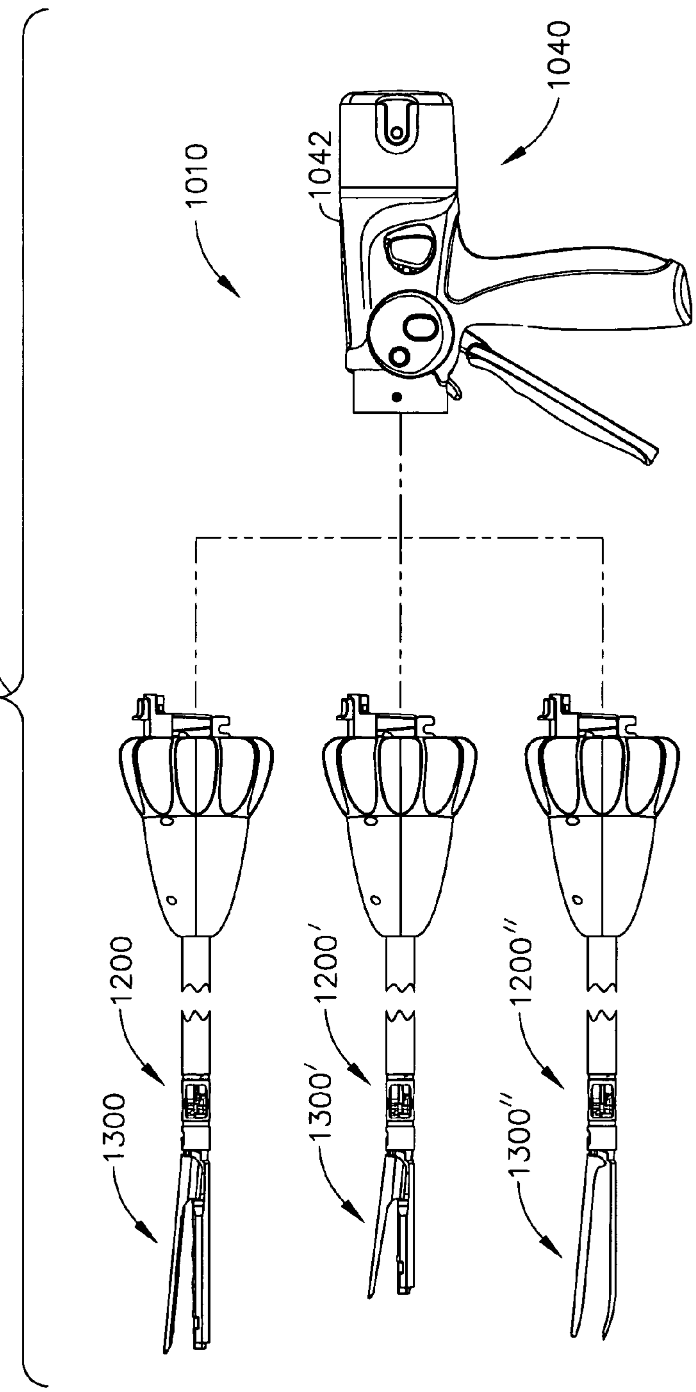



FIG. 33

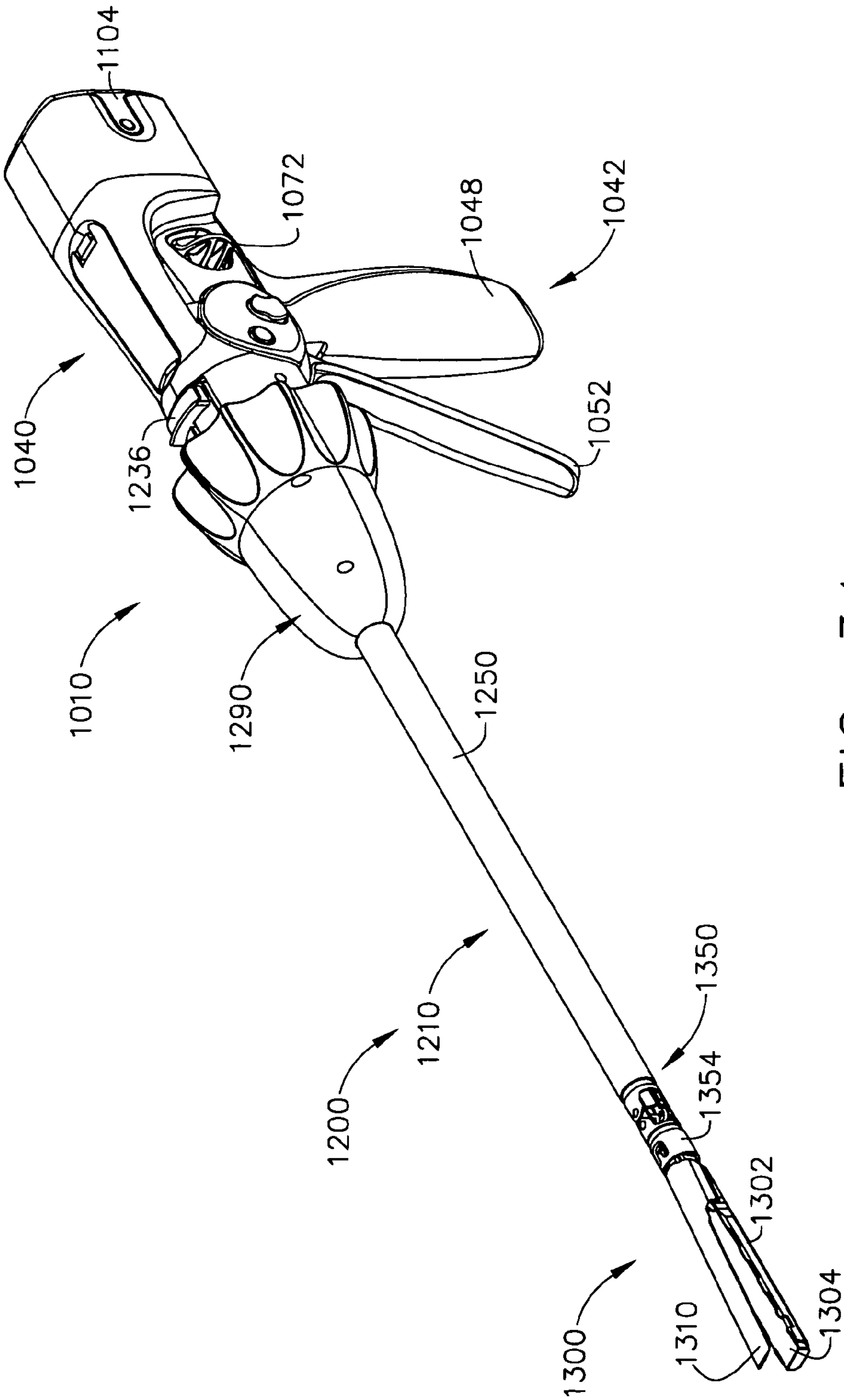

1104
1072
1048
1042
1040
1236
1052
1010
1290
1250
1210
1200
1350
1354
1302
1300
1310
1304

FIG. 34

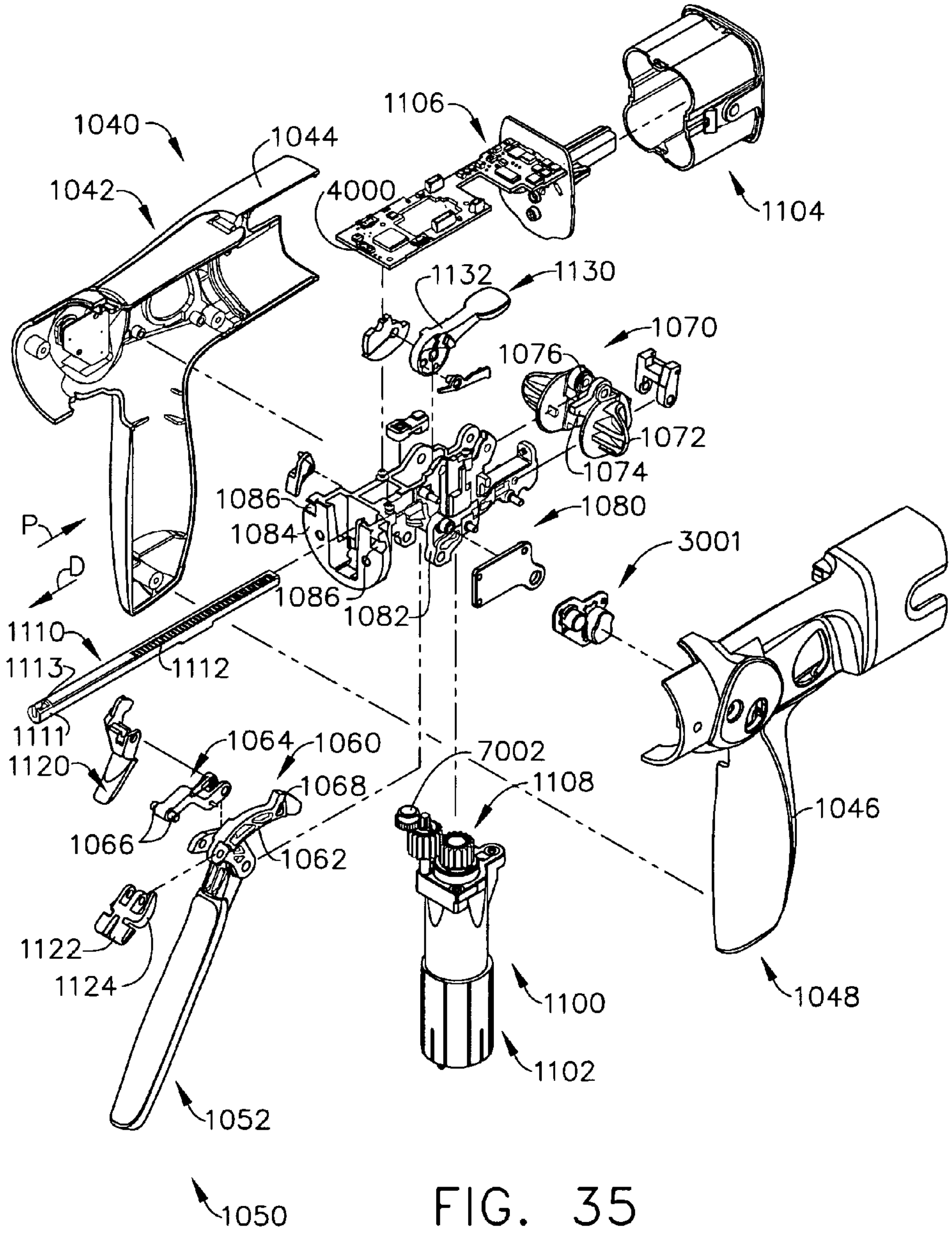

1040
1044
1042
1106
4000
1104
1132
1130
1070
1076
1072
1074
1086
1080
P
1084
3001
D
1086
1082
1110
1113
1112
1111
1120
1064
1060
7002
1068
1108
1046
1066
1062
1122
1124
1100
1048
1102
1052
1050

FIG. 35

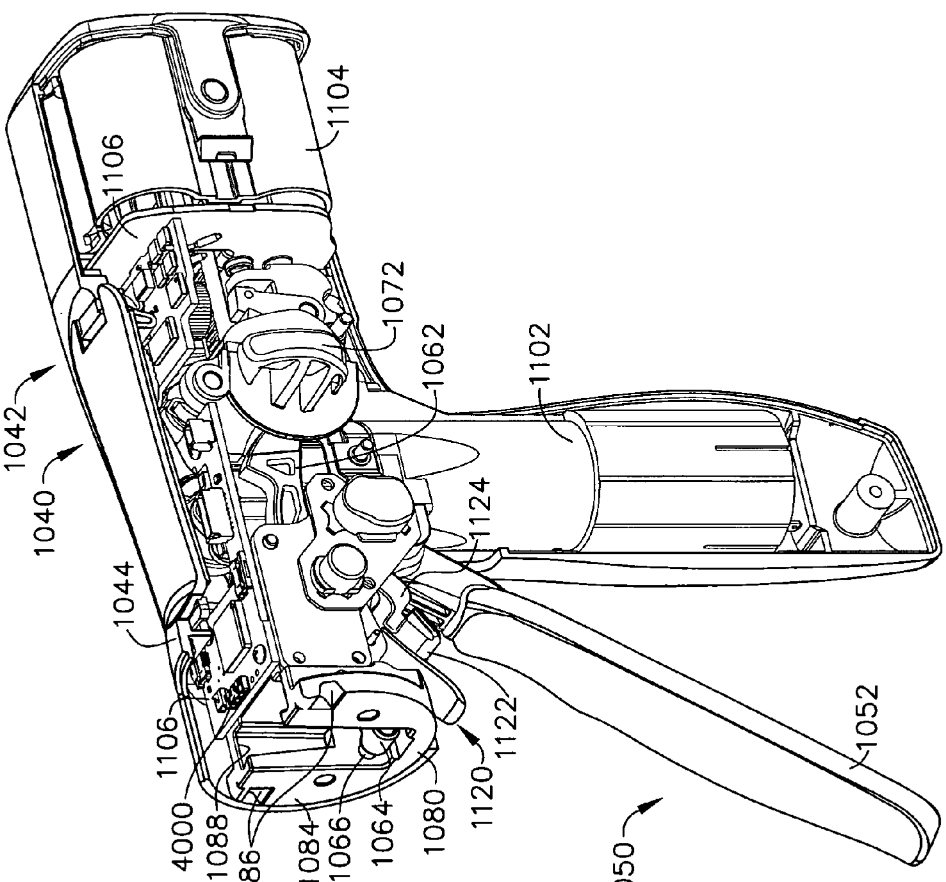

1104
1106
1072
1062
1102
1042
1040
1124
1044
1122
1052
1106
4000
1088
1086
1084
1066
1064
1080
1120
1050

FIG. 36

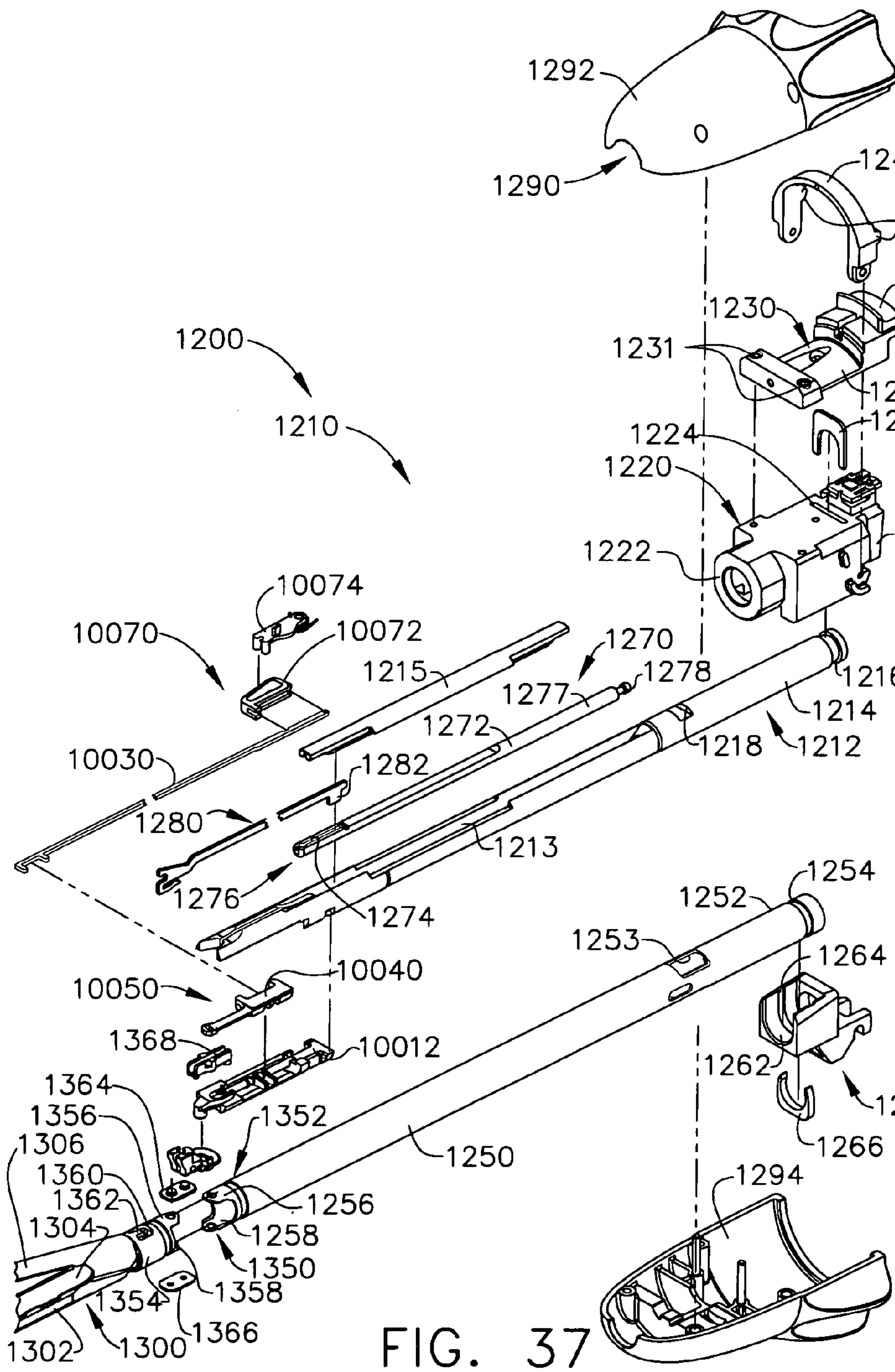

1292
1290
1240
1242
1236
1230
1231
1234
1226
1224
1220
1228
1222
1200
1210
10074
10070
10072
1270
1215
1277
1278
1216
1214
1272
1218
1212
10030
1282
1280
1213
1276
1274
1254
1252
1253
1264
10040
10050
1368
10012
1262
1364
1260
1356
1352
1306
1250
1266
1360
1294
1256
1362
1258
1304
1350
1354
1358
1366
1302
1300

FIG. 37

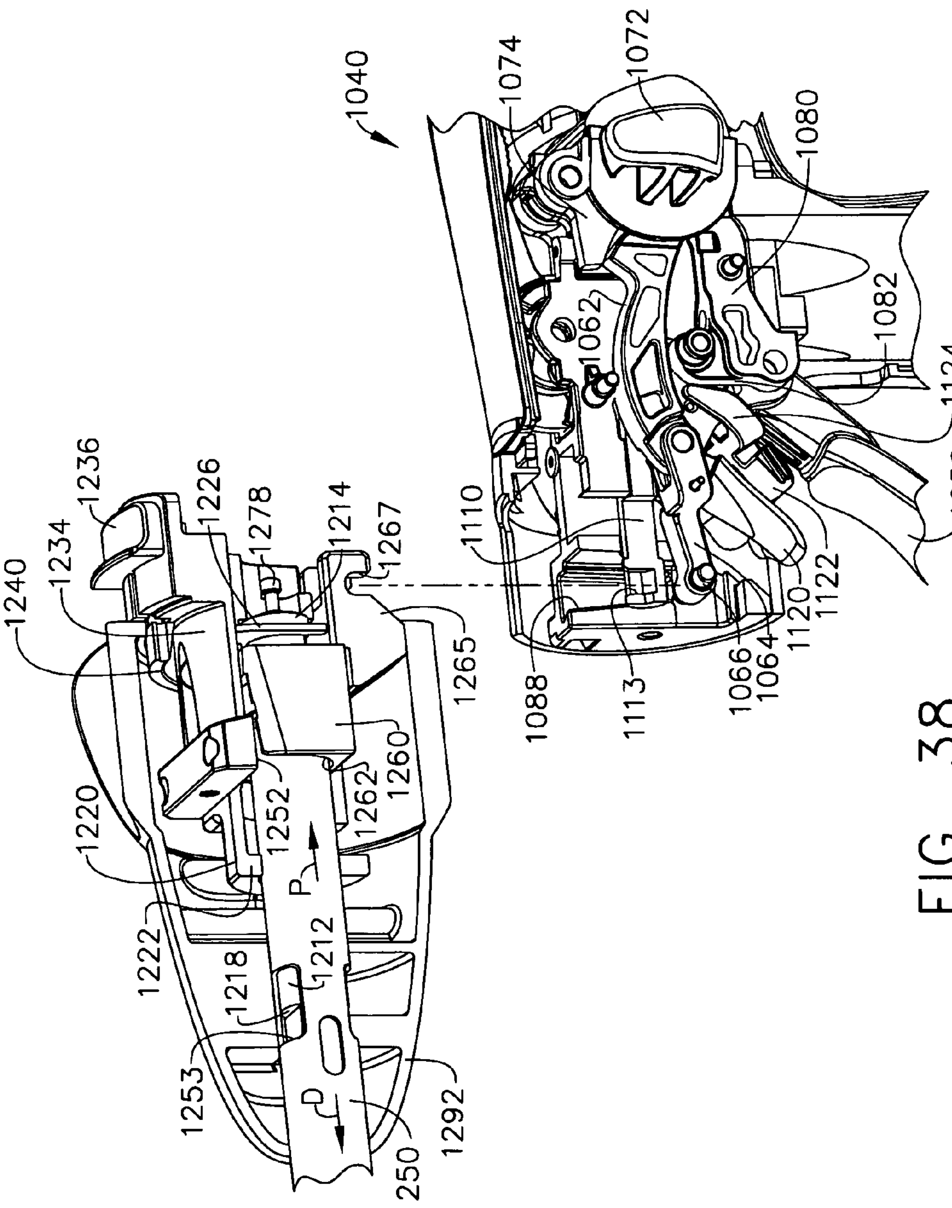

1040
1072
1074
1080
1082
1124
1052
1062
1110
1122
1120
1064
1066
1113
1088
1236
1226
1278
1214
1267
1234
1240
1265
1260
1262
1252
1220
1222
1212
1218
1253
1250
1292
P
D

FIG. 38

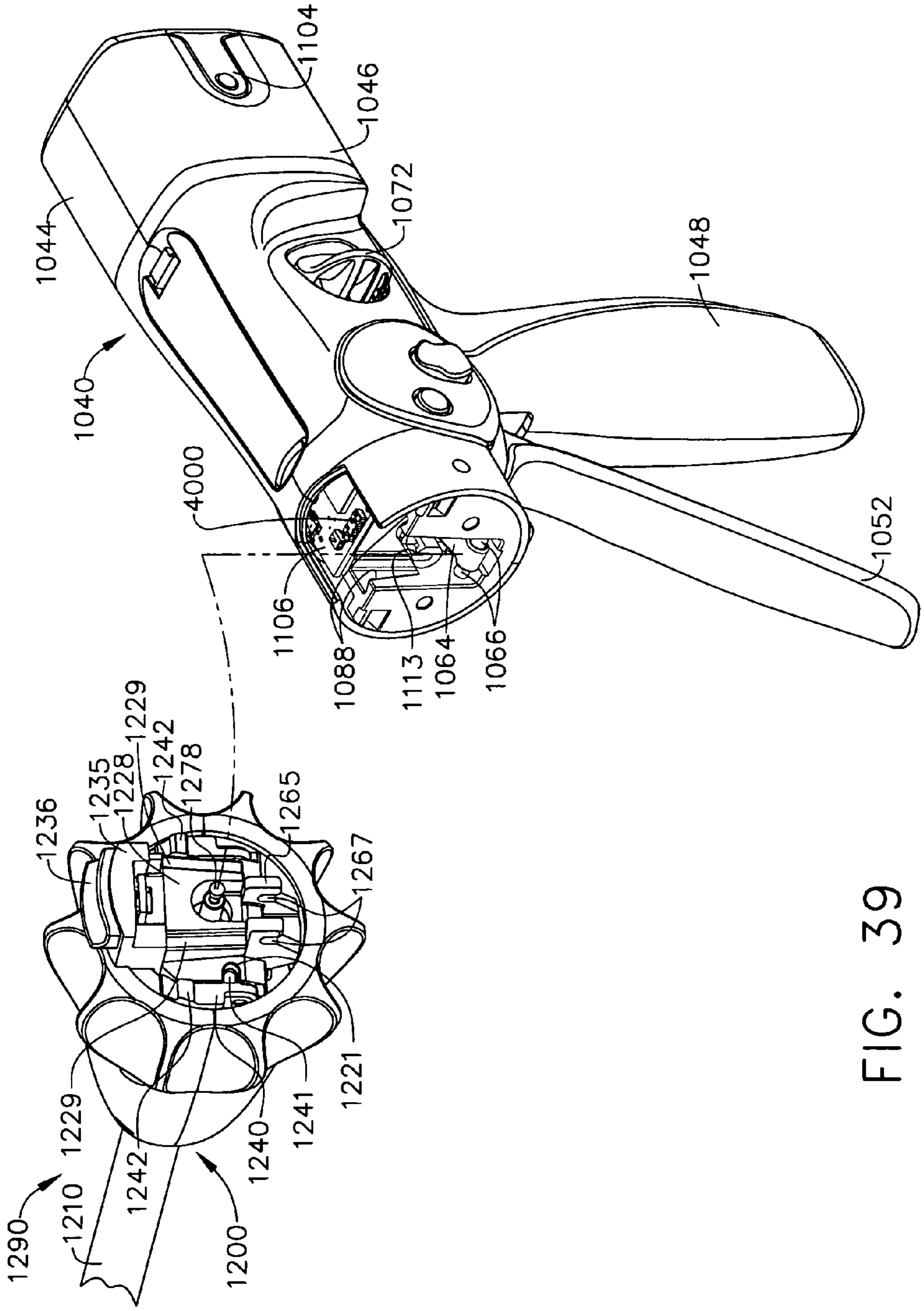

1104
1046
1044
1072
1048
1040
4000
1052
1106
1088
1113
1064
1066
1236
1235
1228
1229
1242
1278
1265
1267
1221
1241
1240
1229
1242
1210
1290
1200

FIG. 39

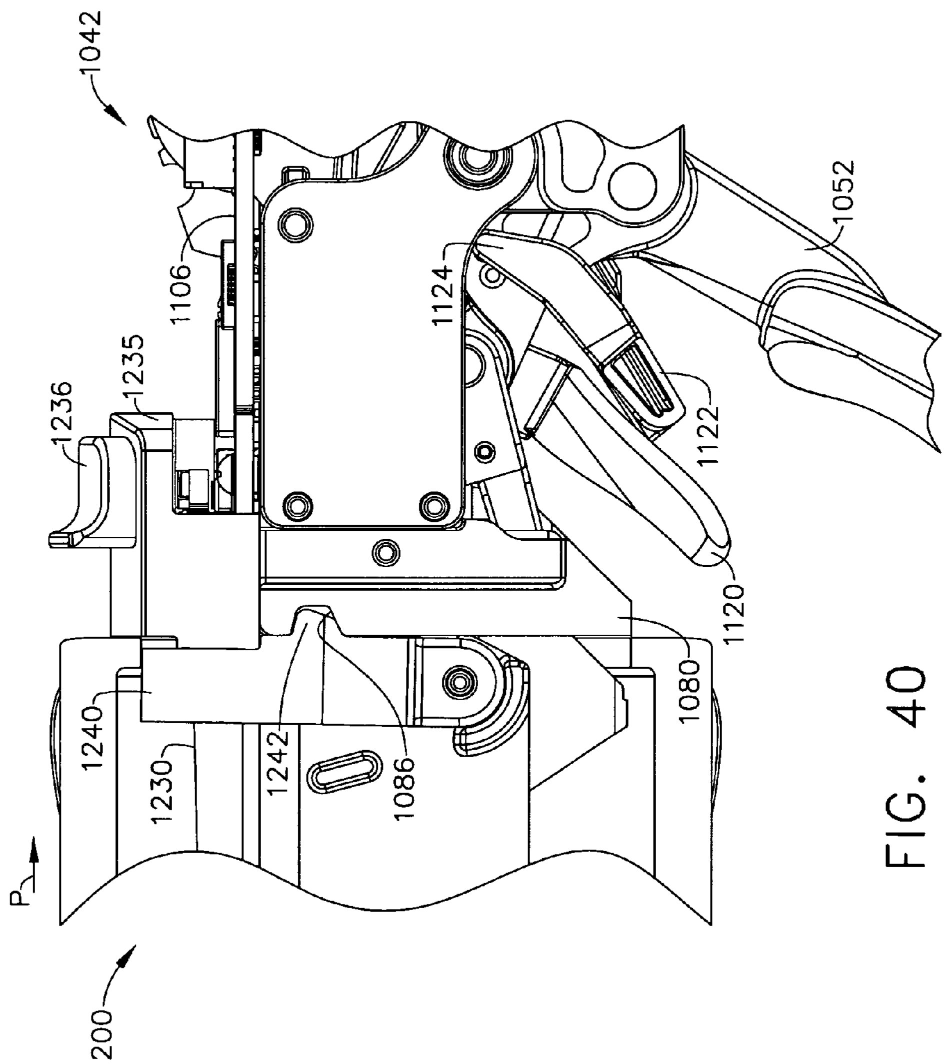

1042
1052
1106
1124
1235
1236
1122
1120
1080
1240
1242
1086
1230
P
1200

FIG. 40

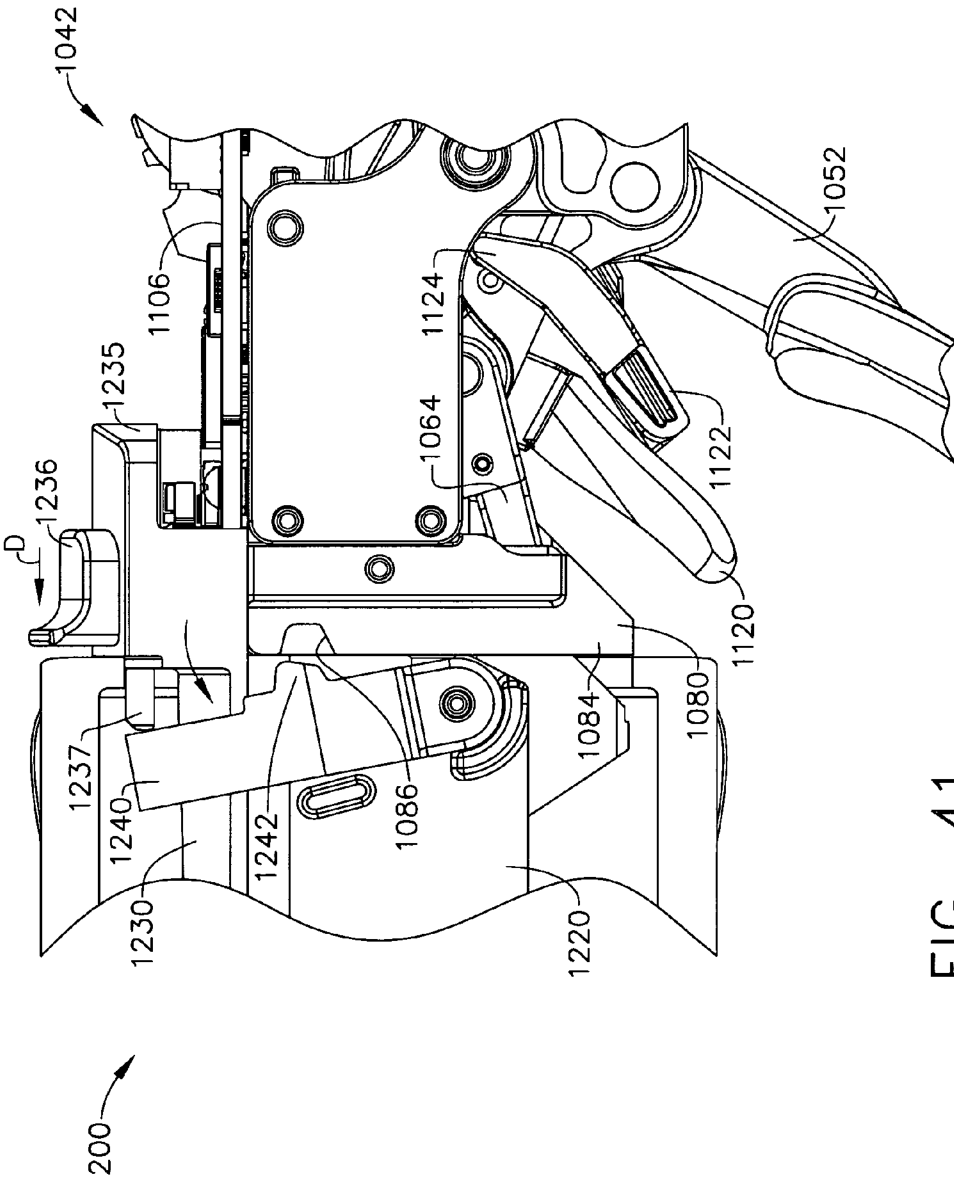

1042
1052
1106
1124
1122
1235
1064
1236
D
1120
1080
1084
1237
1240
1242
1086
1230
1220
1200

FIG. 41

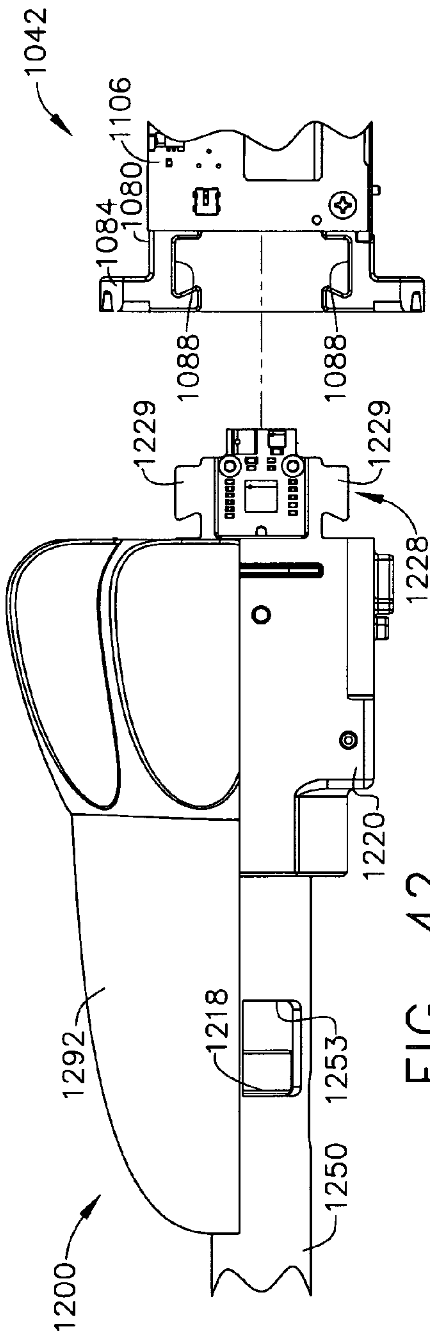

1042
1106
1080
1084
1088
1088
1229
1229
1228
1220
1292
1218
1253
1250
1200

FIG. 42

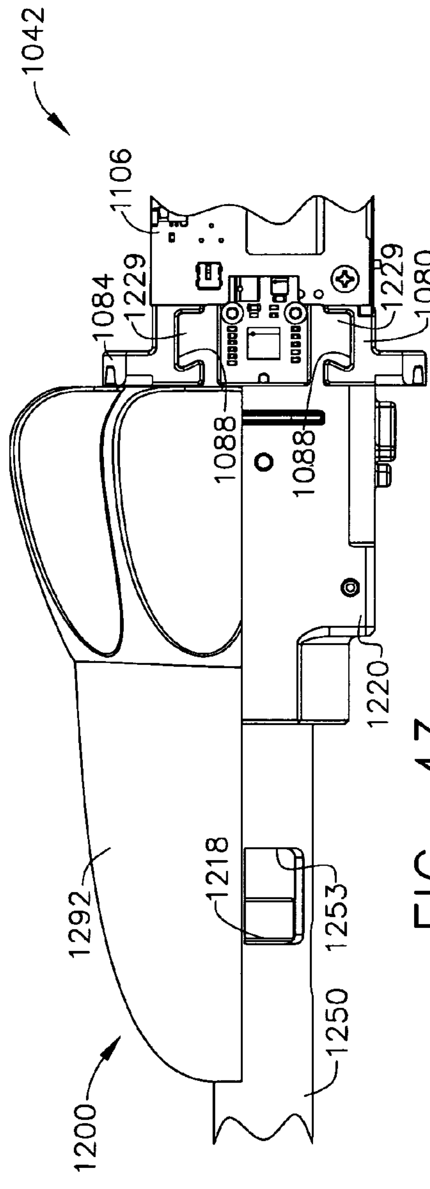

1042
1106
1084
1229
1229
1080
1088
1088
1220
1292
1218
1253
1250
1200

FIG. 43

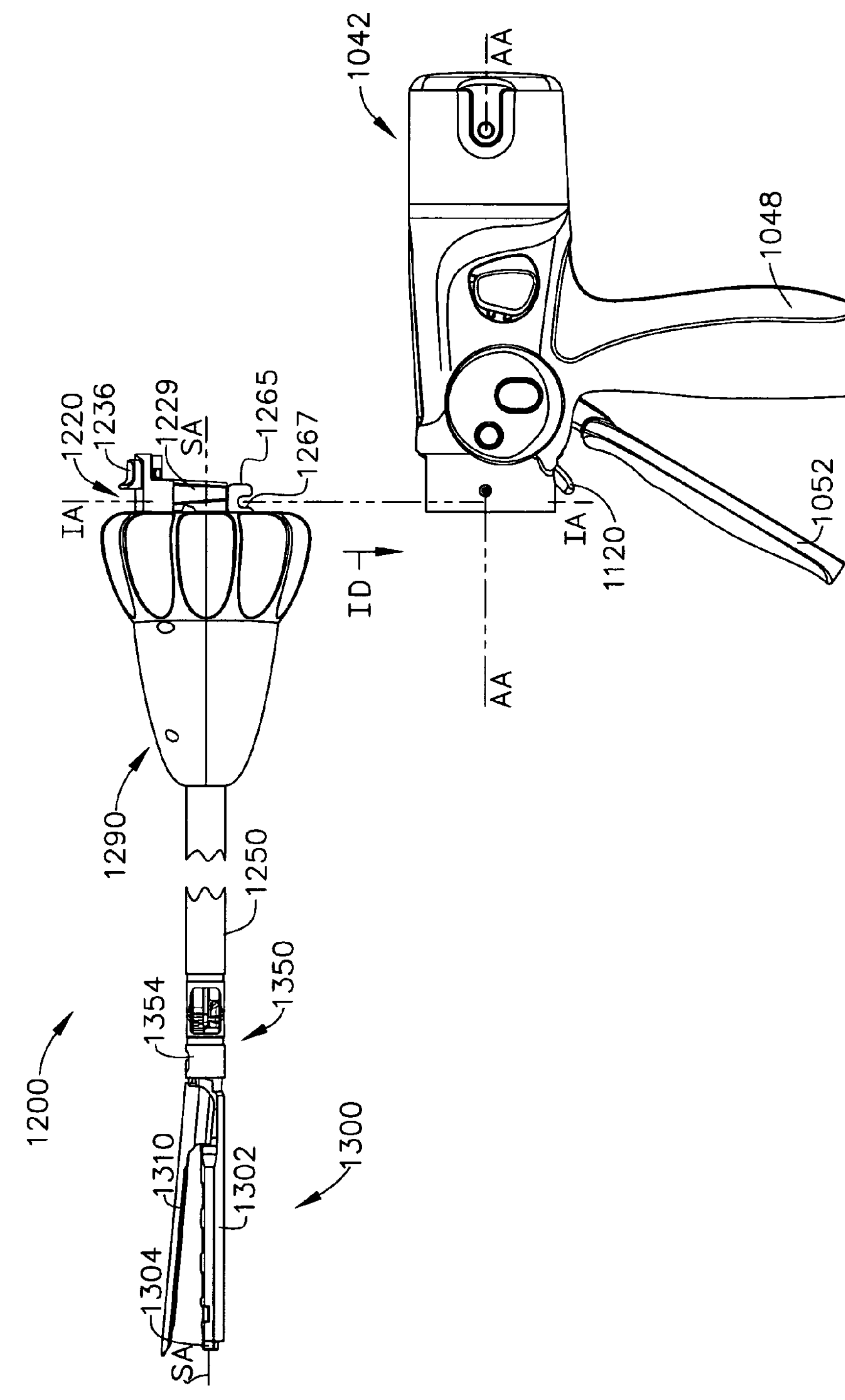

1042
AA
1048
1052
1120
IA
ID
AA
1220
1236
1229
SA
1265
1267
IA
1290
1250
1250
1350
1354
1200
1300
1310
1302
1304
SA

FIG. 44

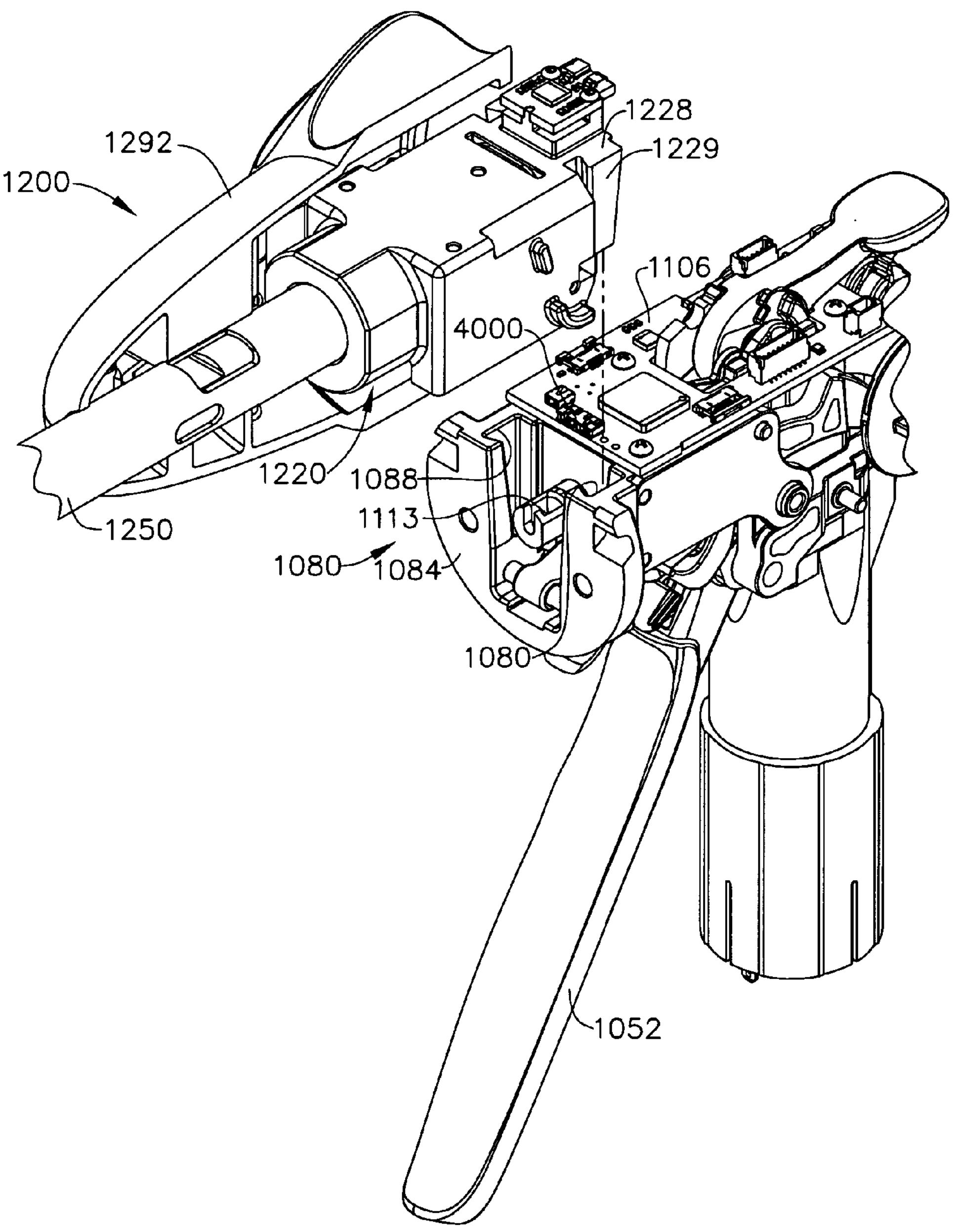

1228
1229
1292
1200
1106
4000
1220
1088
1250
1113
1080
1084
1080
1052

FIG. 45

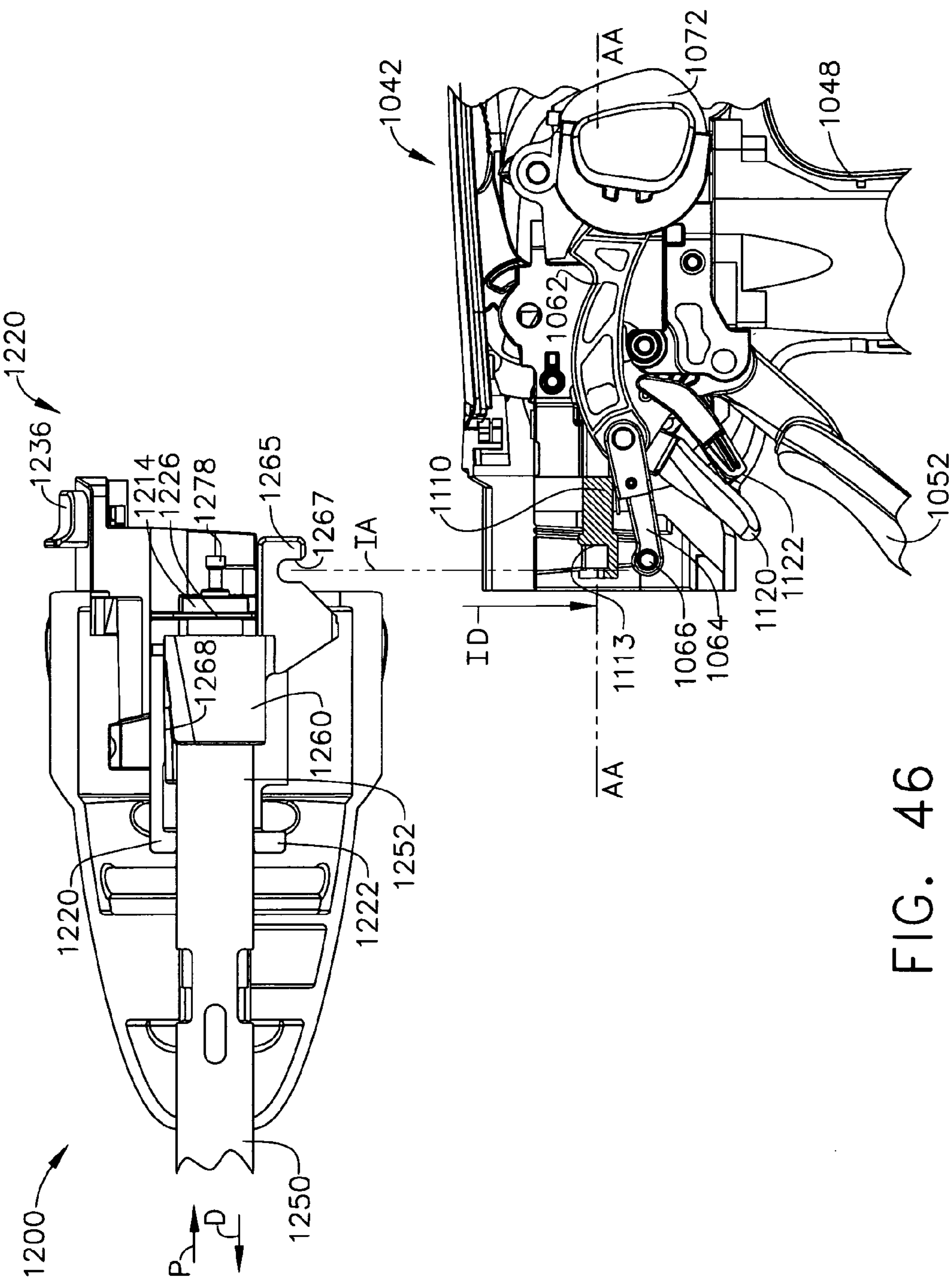

1200
1220
1236
1214
1226
1278
1265
1267
IA
1268
1260
1252
1220
1222
1250
P
D
1042
1072
AA
1048
1062
1110
1052
1122
1120
1064
1066
1113
ID
AA

FIG. 46

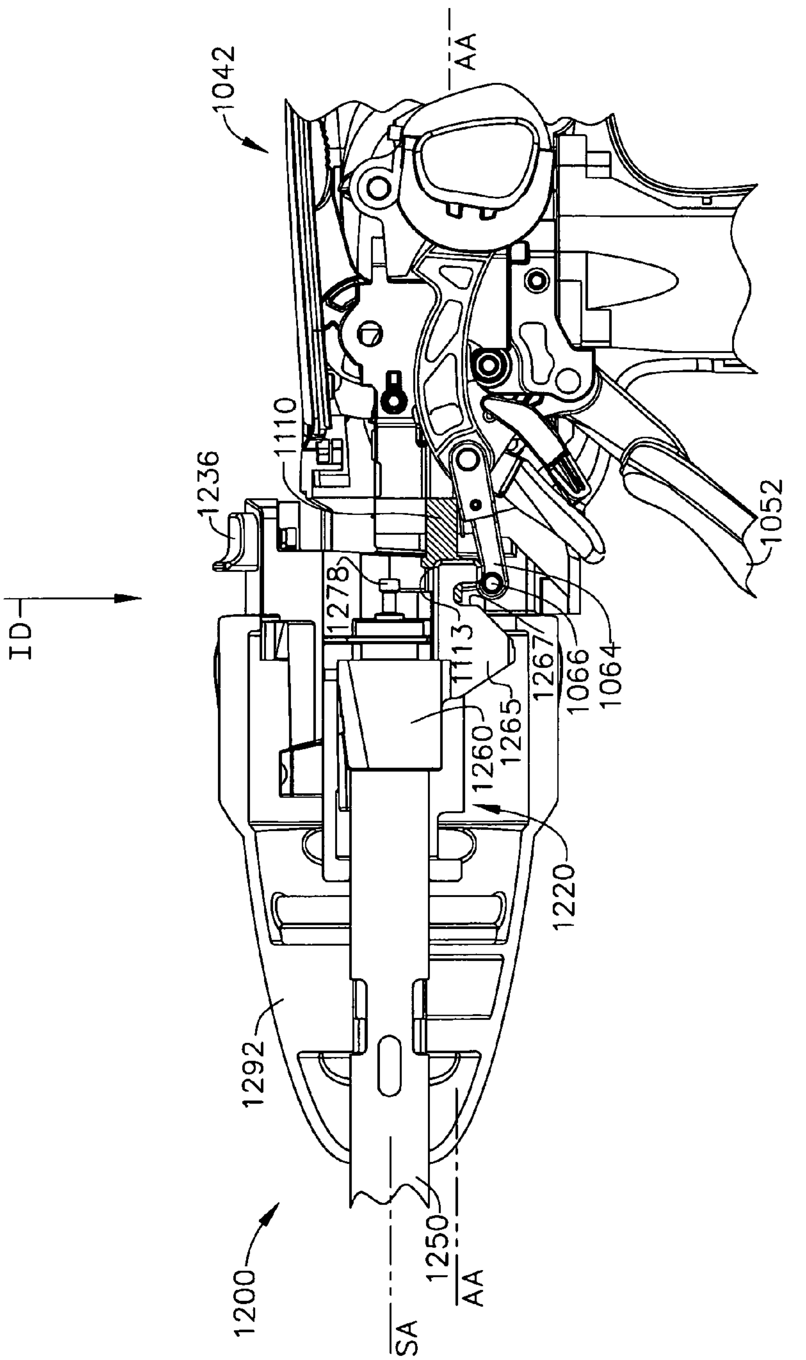

1042
AA
1110
1236
1052
ID
1278
1113
1267
1066
1064
1260
1265
1220
1292
1250
AA
1200
SA

FIG. 47

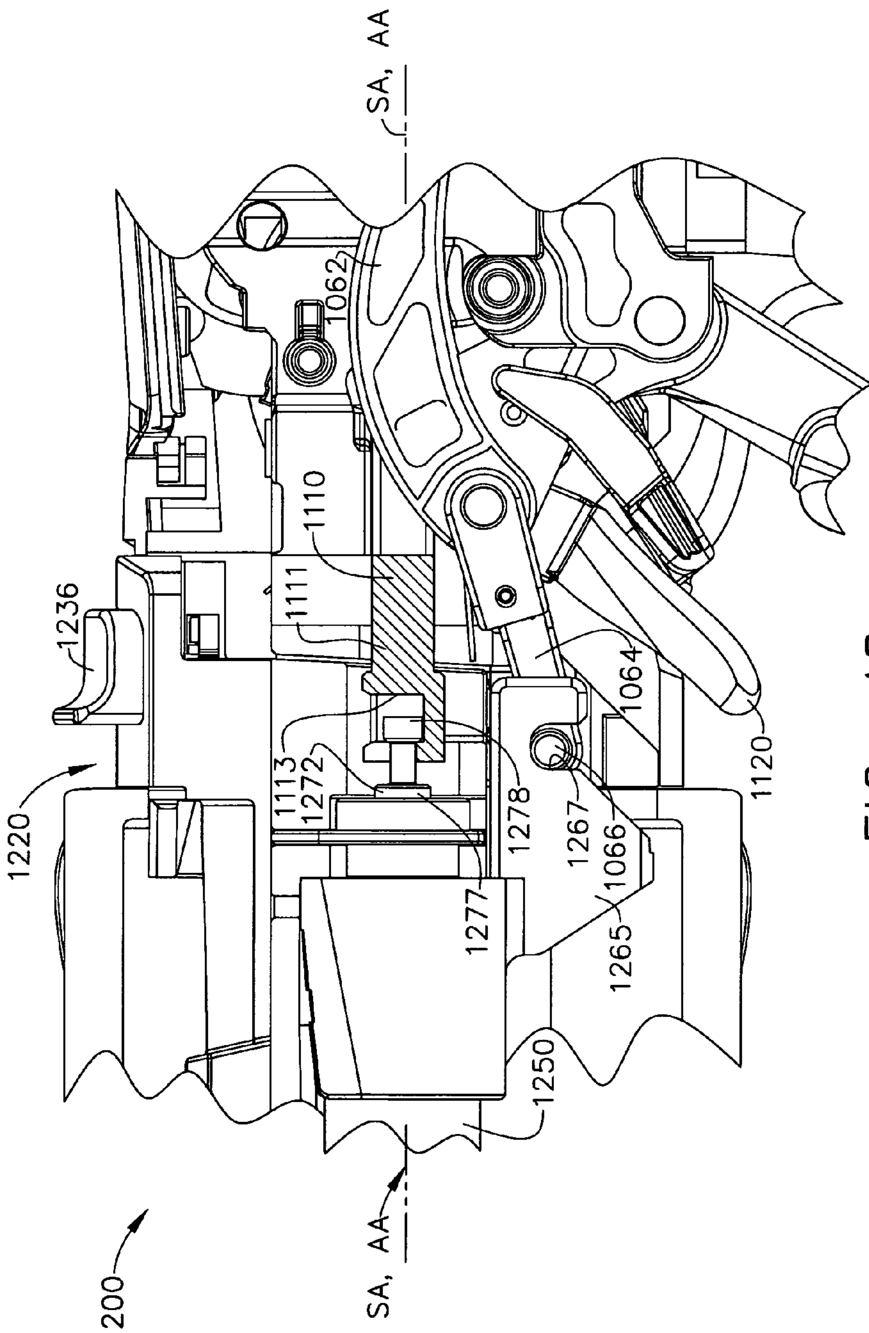

SA, AA
1062
1110
1111
1236
1220
1113
1272
1278
1064
1120
1267
1066
1265
1277
1250
SA, AA
1200

FIG. 48

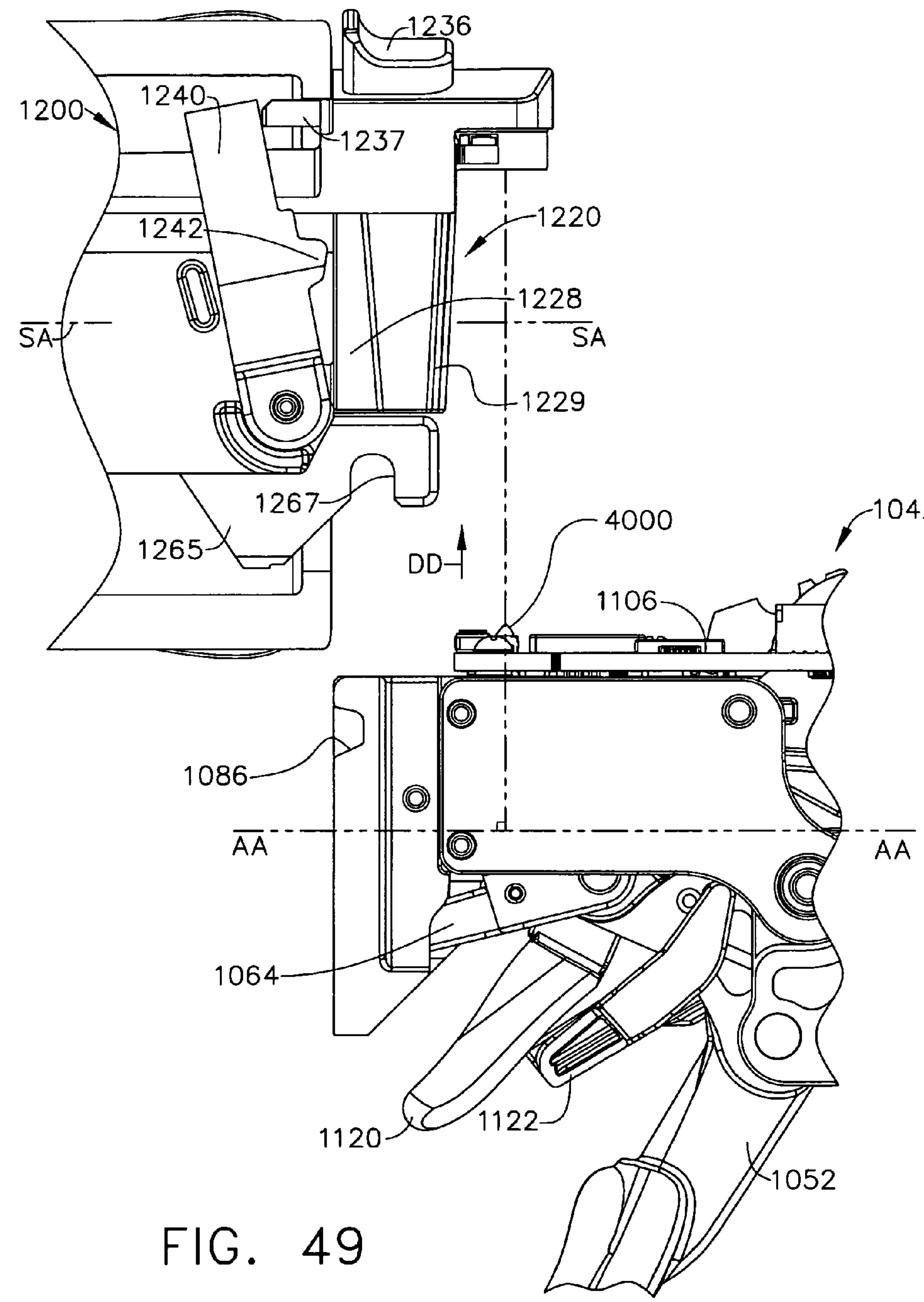

1236
1200
1240
1237
1220
1242
1228
SA
SA
1229
1267
1265
DD
4000
1042
1106
1086
AA
AA
1064
1120
1122
1052

FIG. 49

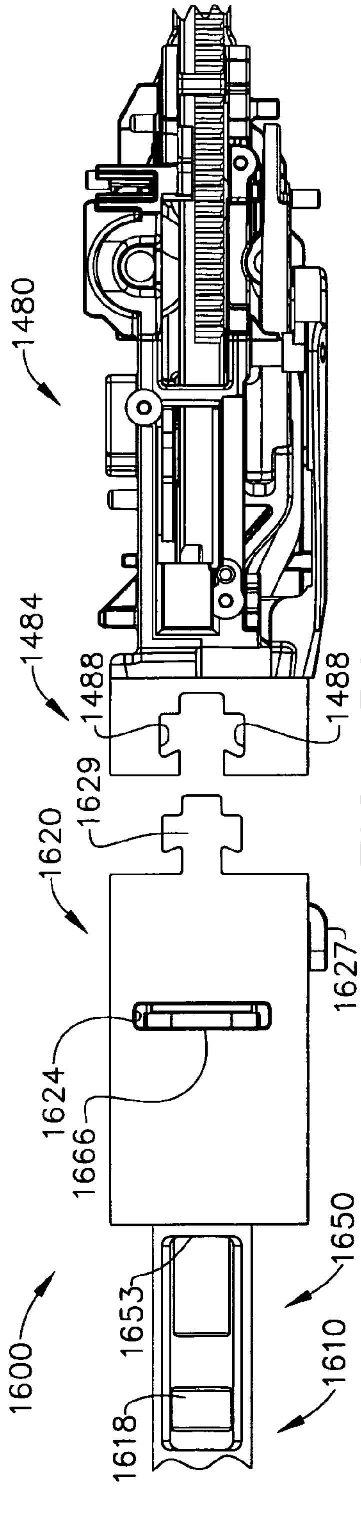

1480
1484
1488
1488
1629
1620
1627
1624
1666
1650
1653
1600
1610
1618

FIG. 50

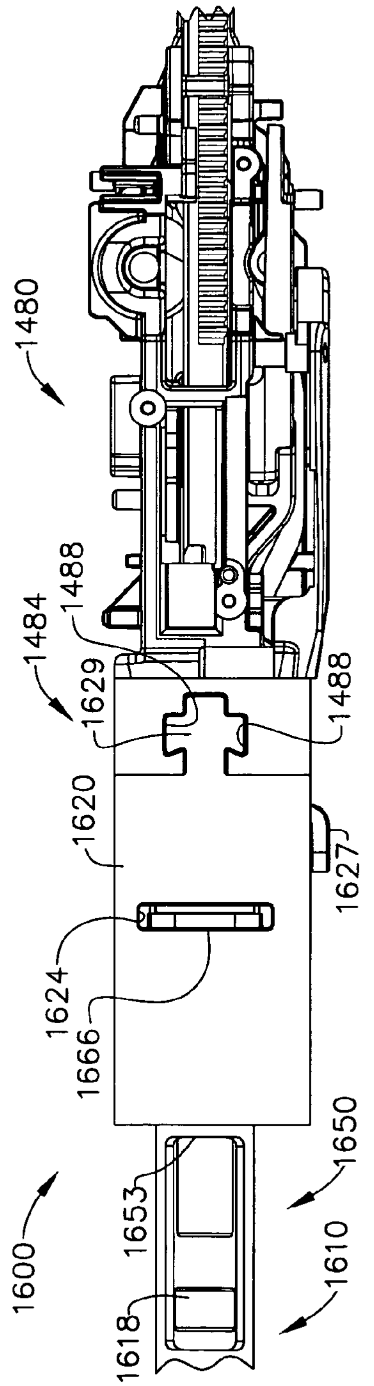

1480
1484
1488
1629
1488
1620
1627
1624
1666
1650
1653
1600
1610
1618

FIG. 51

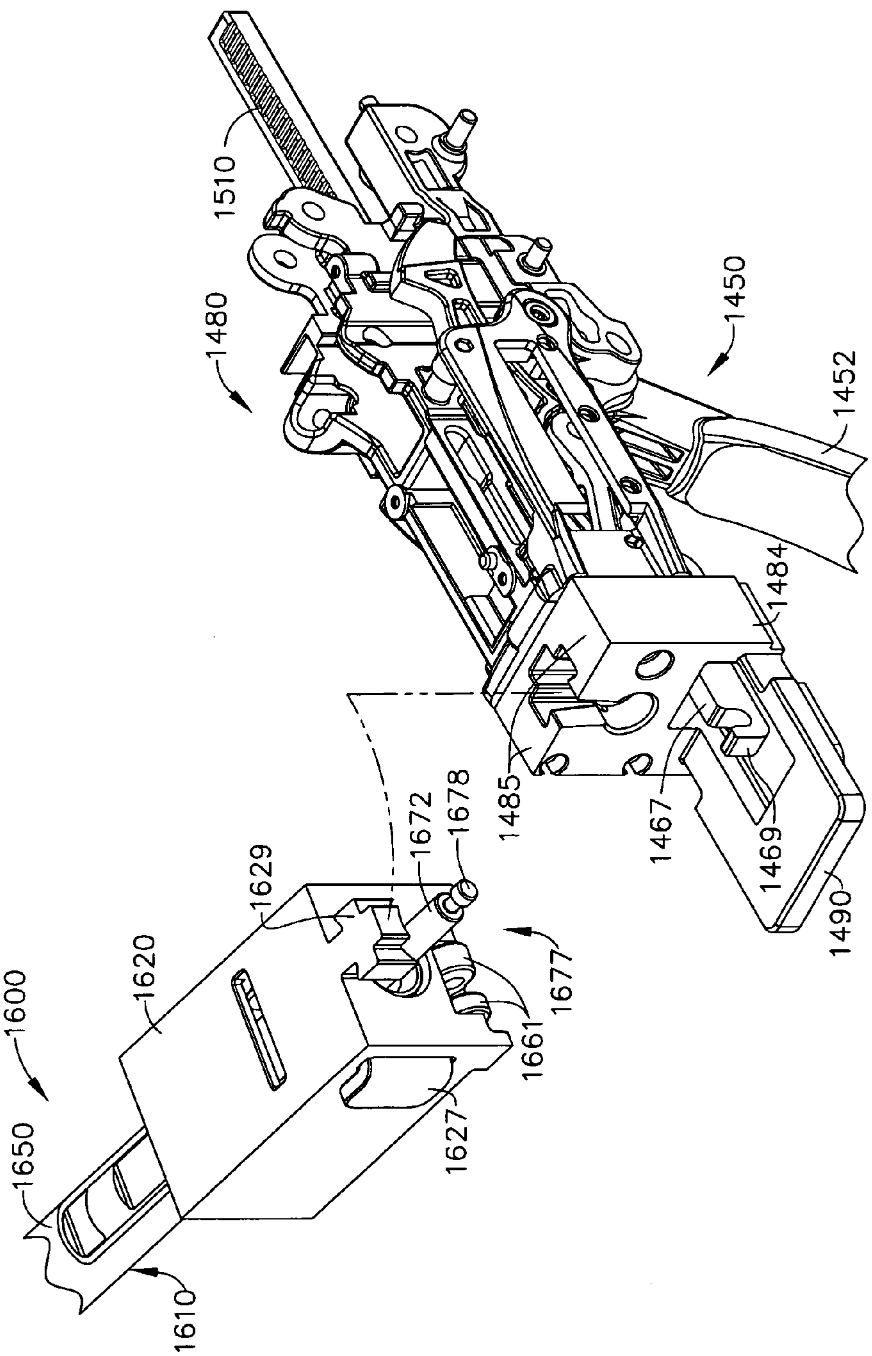

1510
1480
1450
1452
1484
1485
1467
1469
1490
1678
1672
1629
1620
1600
1677
1661
1627
1650
1610

FIG. 52

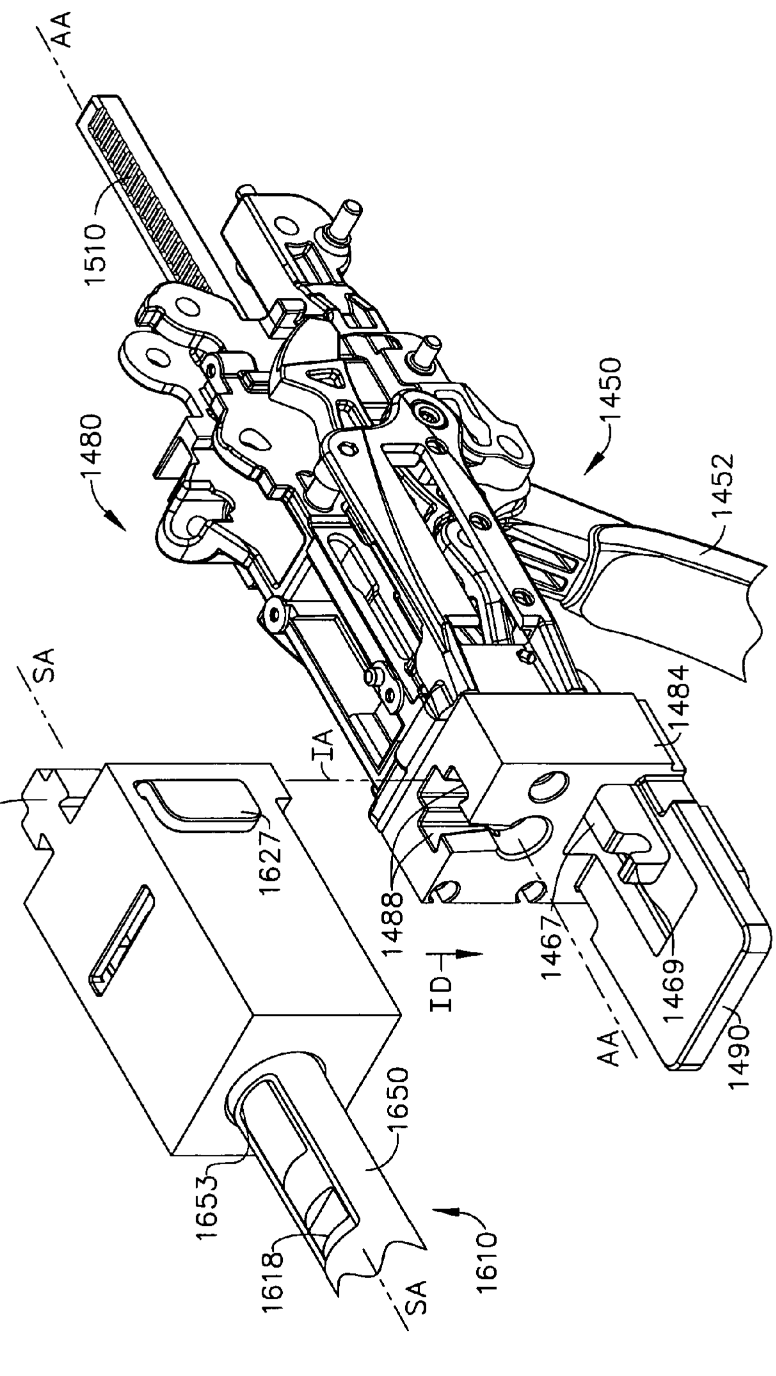
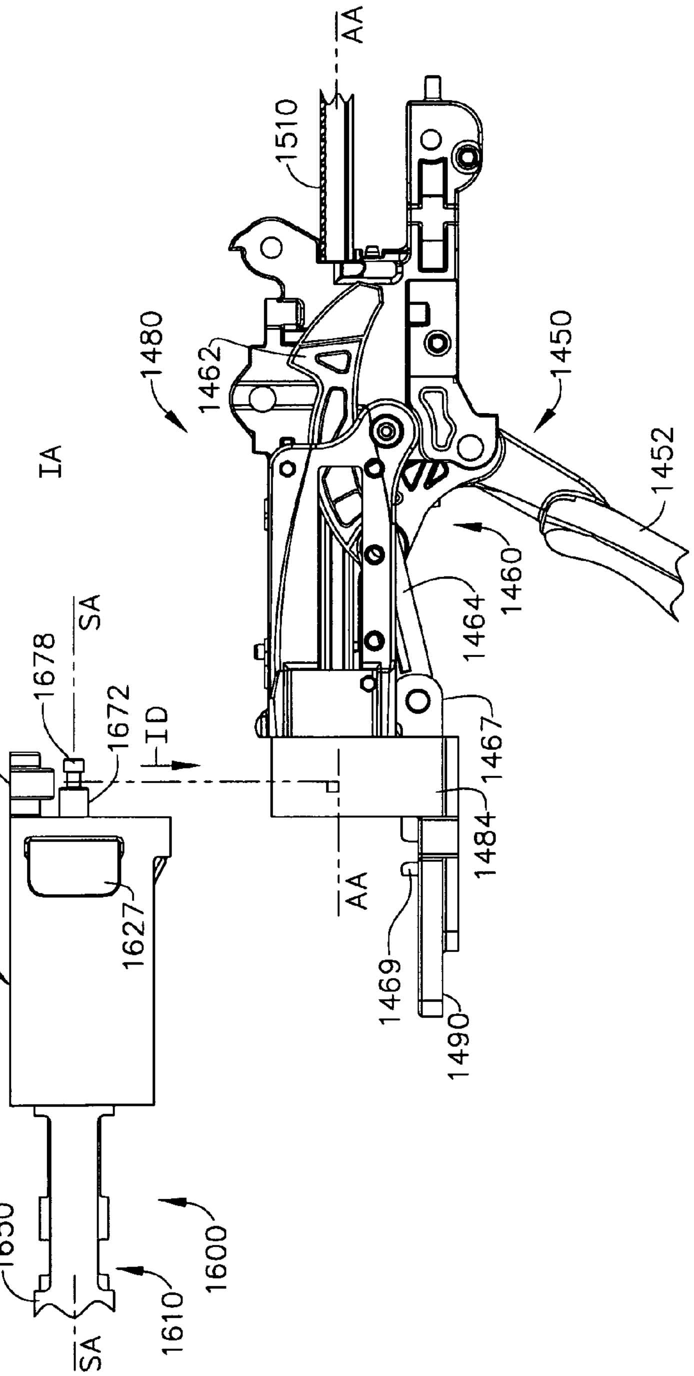

AA
1510
1480
1450
1452
1484
SA
1629
IA
1627
1488
1467
1469
1490
AA
ID
1650
1653
1618
1610
SA

FIG. 53



AA
1510
1480
1462
1450
1452
1460
1464
1467
1484
1469
1490
IA
SA
1629
1678
1672
ID
1620
1627
1650
1610
1600


FIG. 54

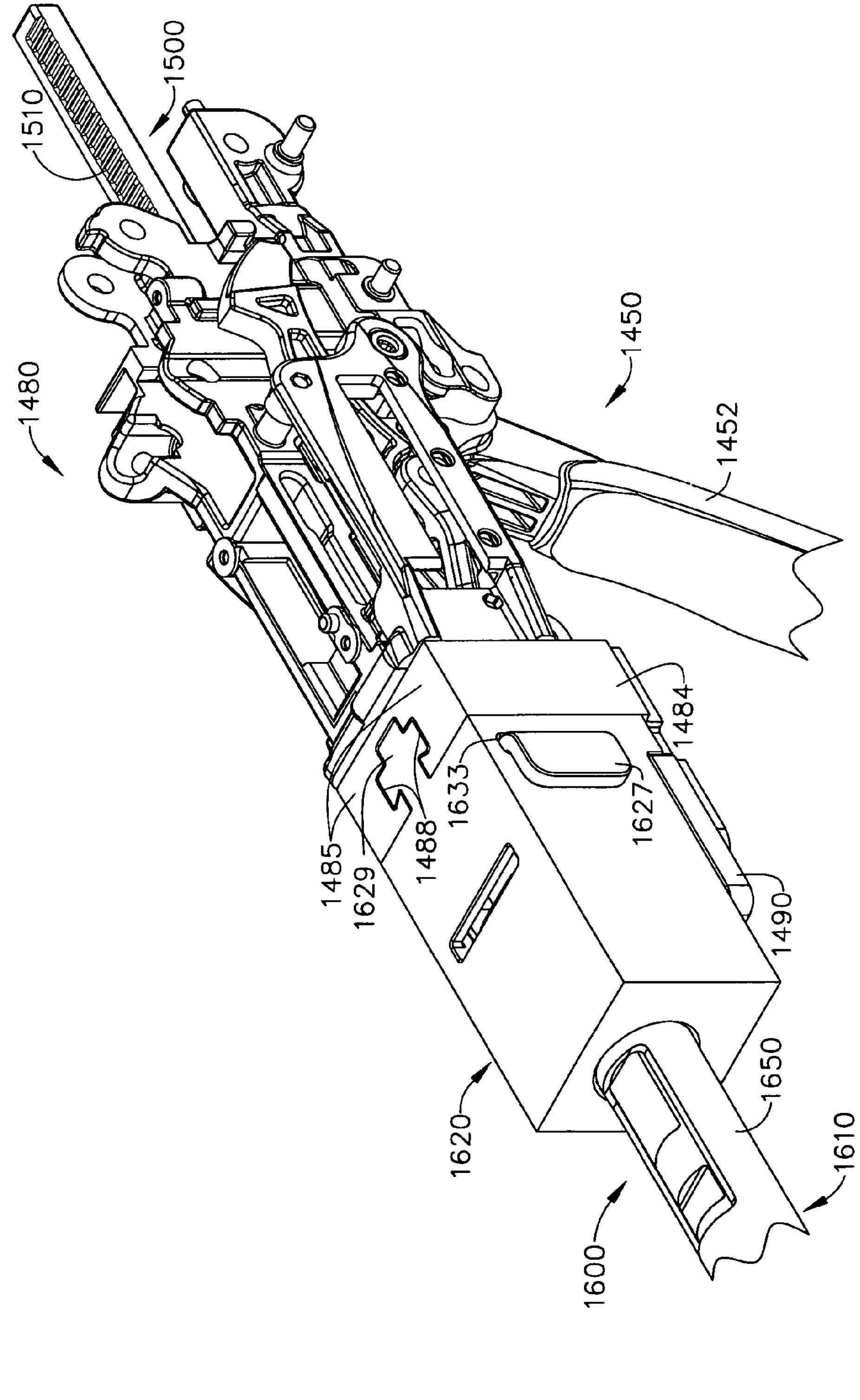

1510
1500
1480
1450
1452
1484
1633
1627
1485
1629
1488
1490
1620
1650
1610
1600

FIG. 55

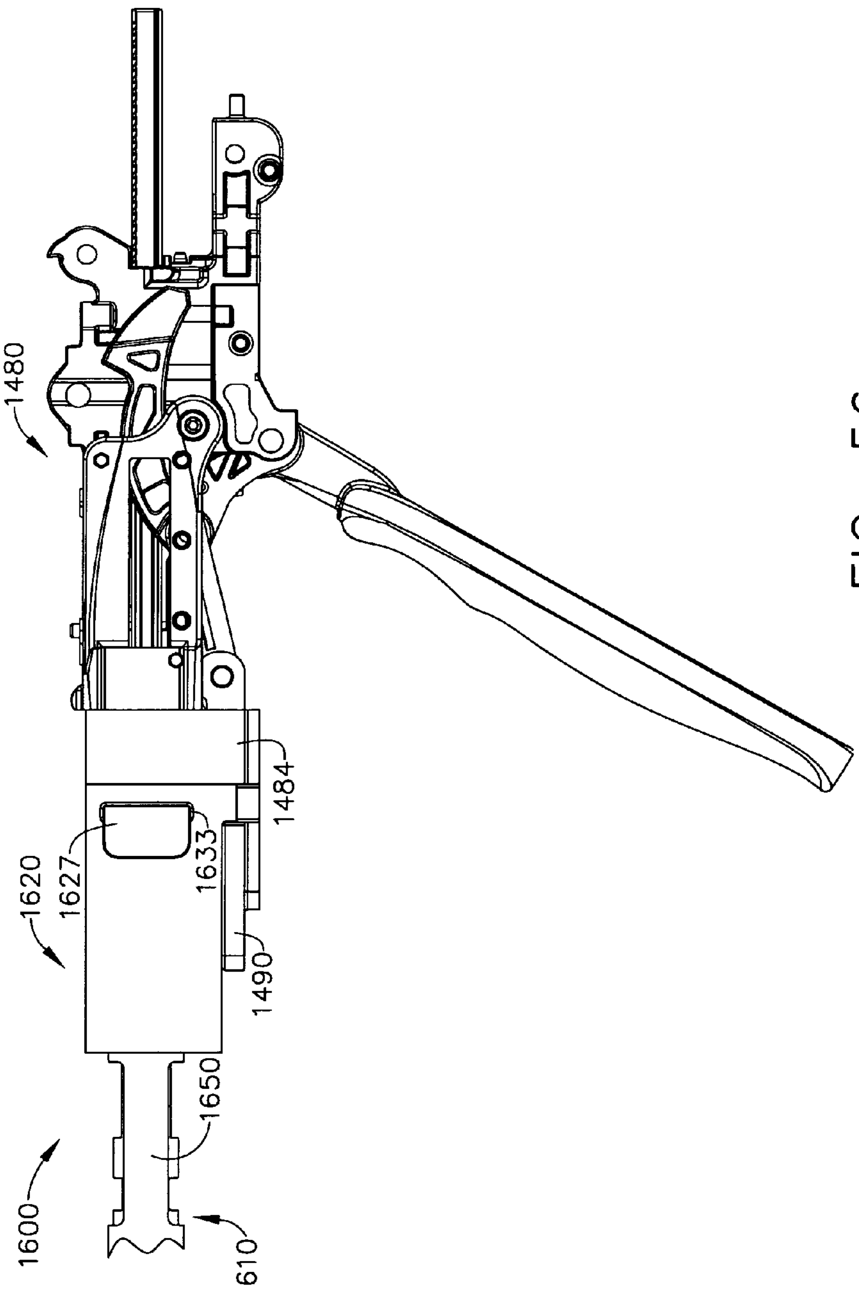



FIG. 56

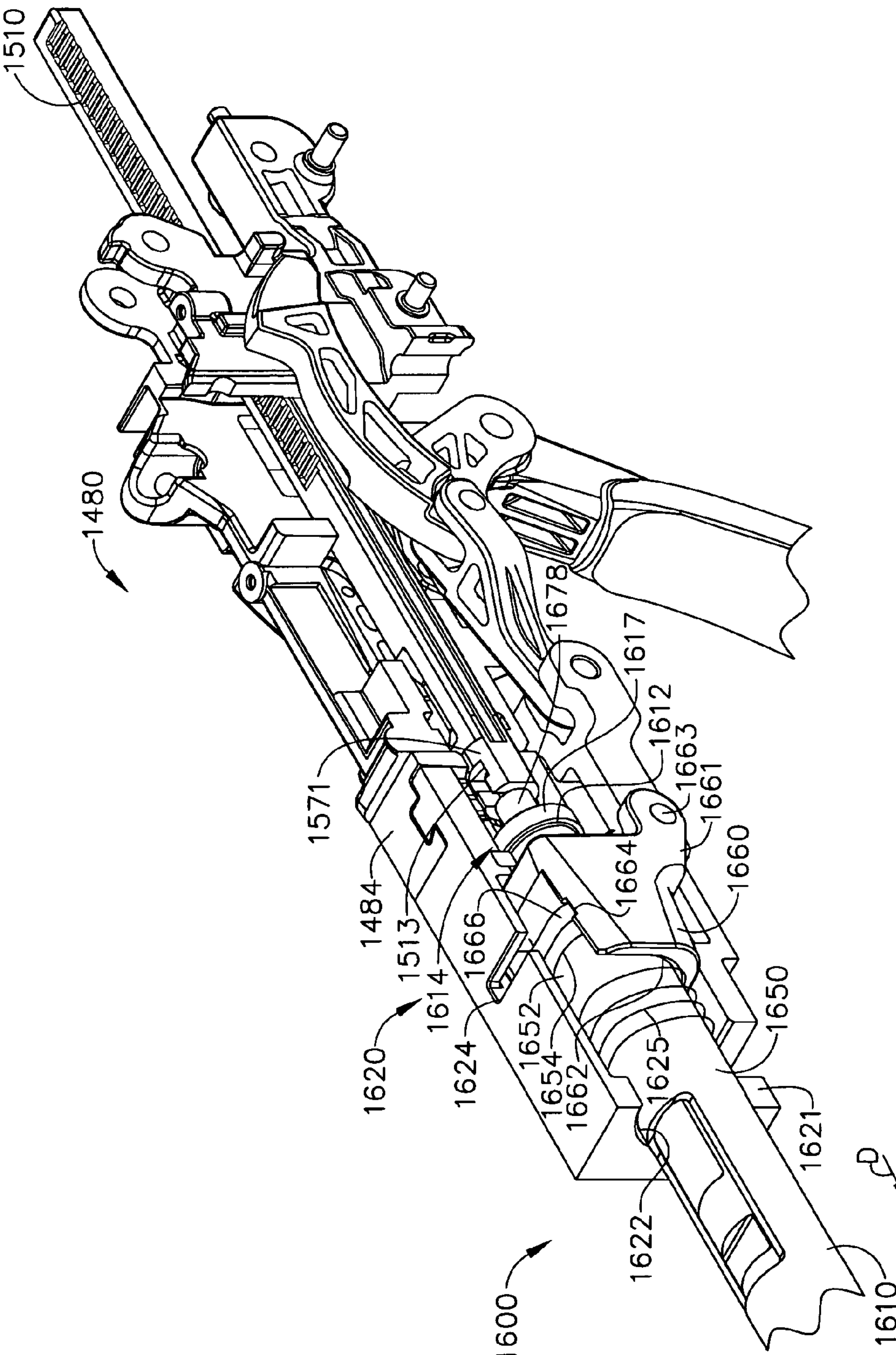

1510
1480
1678
1617
1612
1663
1661
1571
1664
1660
1484
1513
1666
1614
1650
1620
1624
1652
1654
1662
1625
1621
D
P
1622
1600
1610

FIG. 57

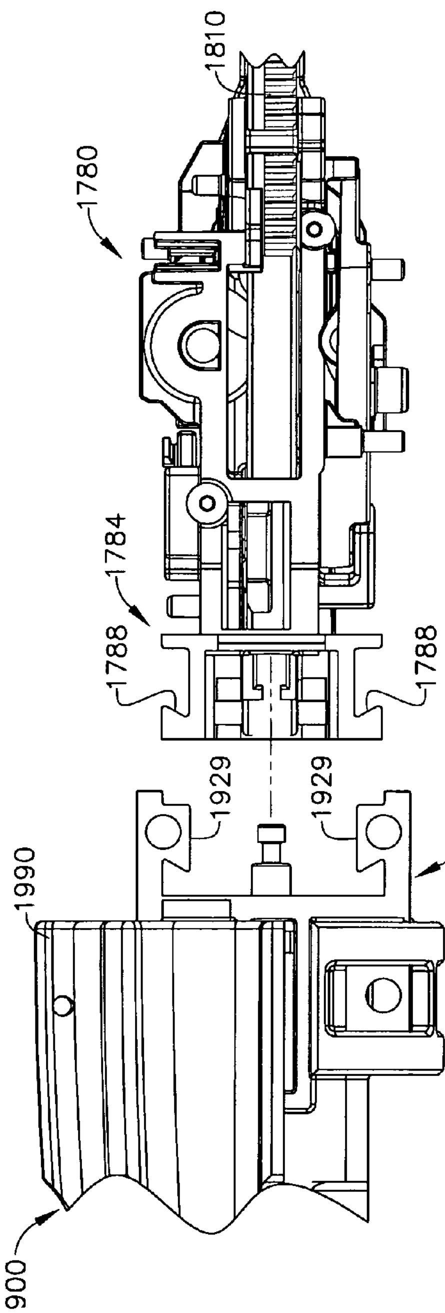

1780
1810
1784
1788
1788
1929
1929
1920
1990
1900

FIG. 58

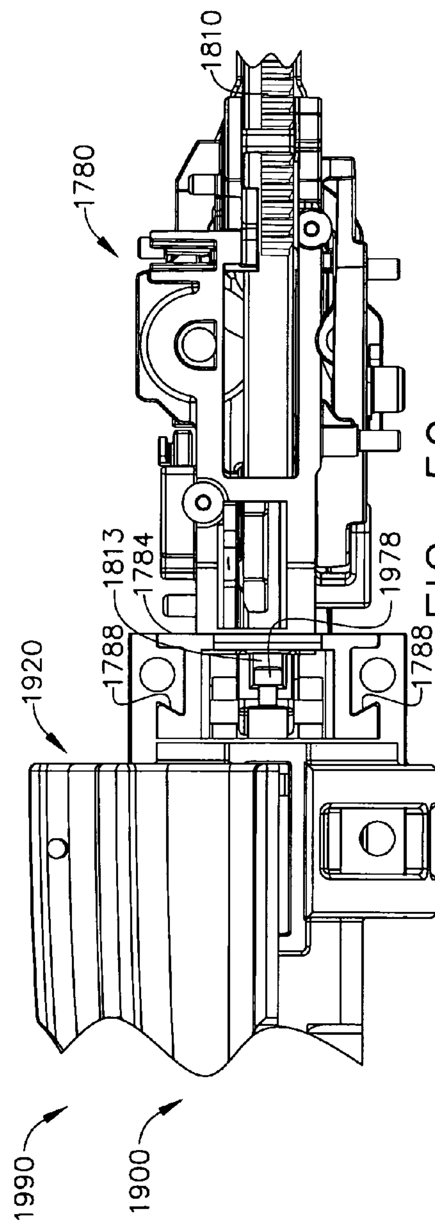

1810
1780
1813
1784
1978
1788
1788
1920
1990
1900

FIG. 59

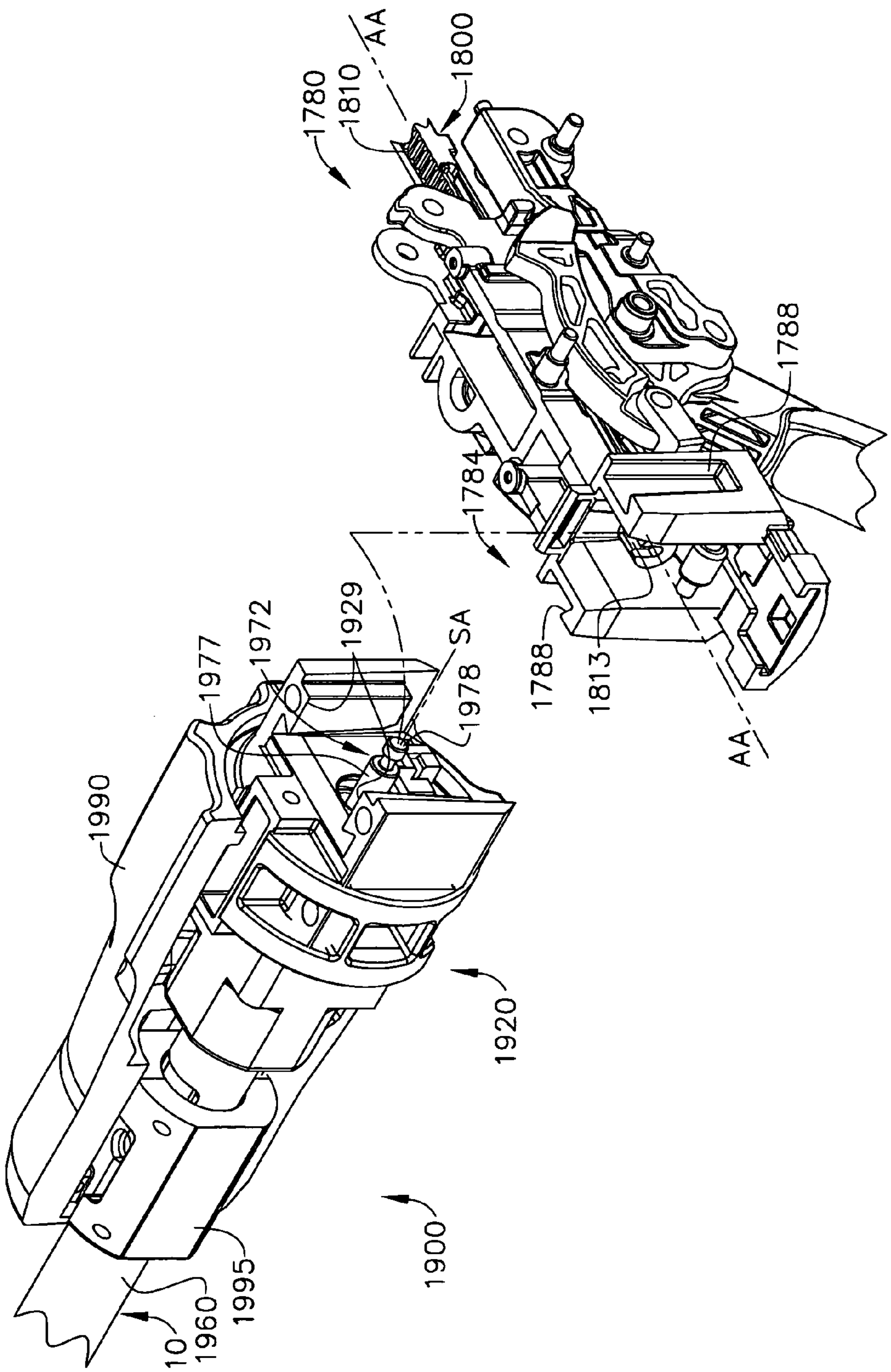

1780
1810
AA
1800
1788
1784
1788
1813
AA
1977
1972
1929
SA
1978
1990
1920
1900
1995
1960
1910

FIG. 60

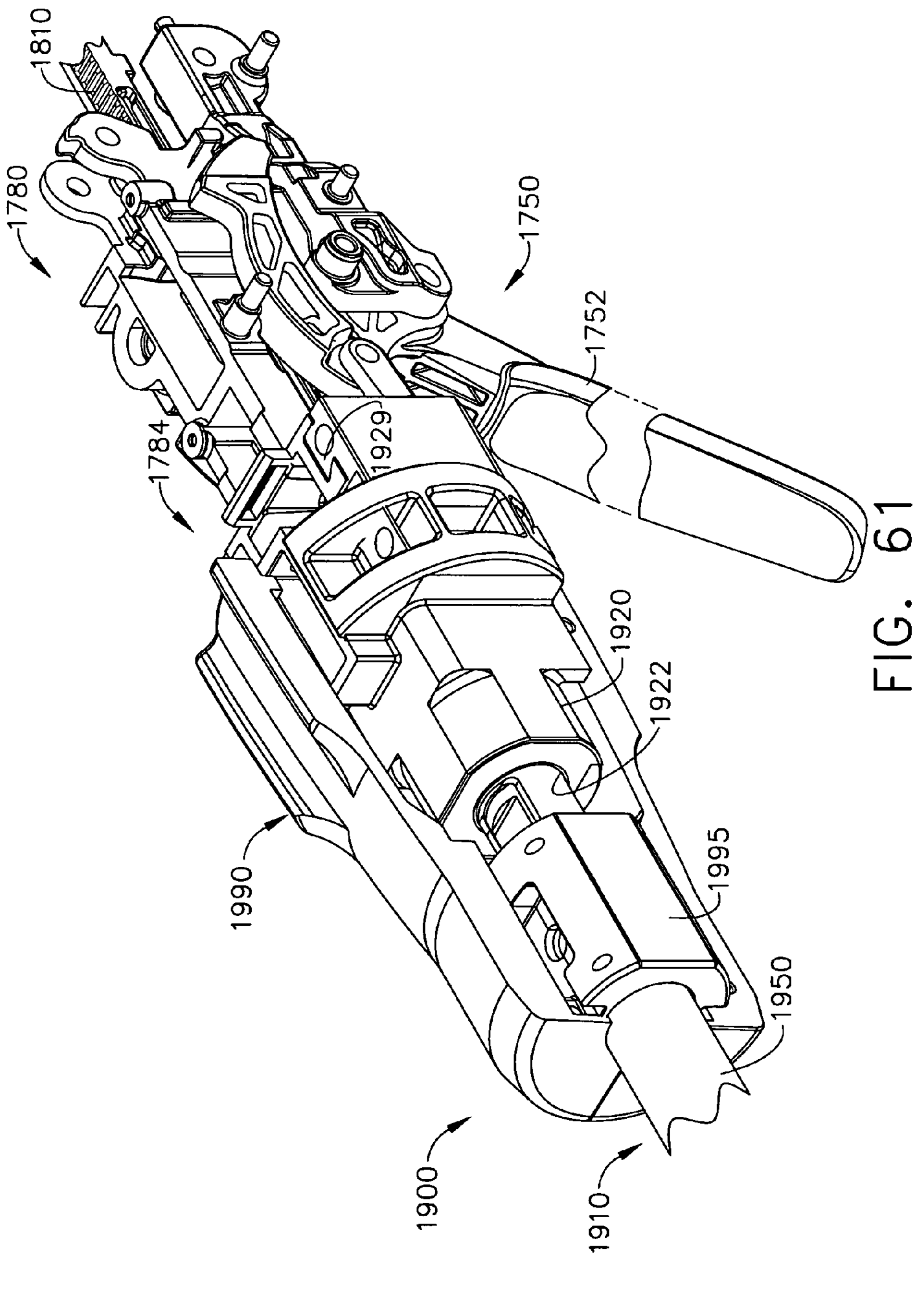

1810
1780
1750
1752
1784
1929
1920
1922
1995
1990
1950
1900
1910

FIG. 61

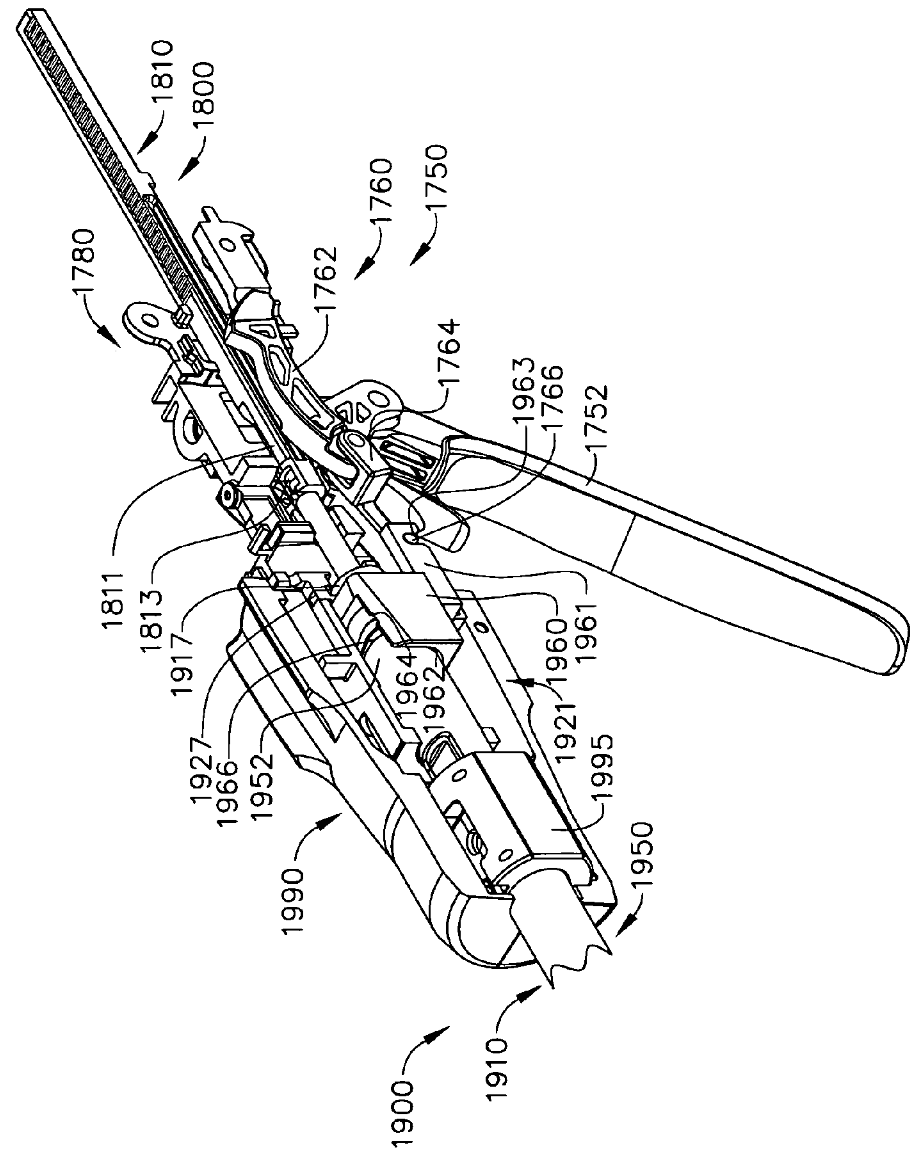

1810
1800
1760
1750
1780
1762
1764
1963
1766
1752
1811
1813
1917
1927
1966
1952
1964
1962
1960
1961
1921
1995
1990
1950
1900
1910

FIG. 62

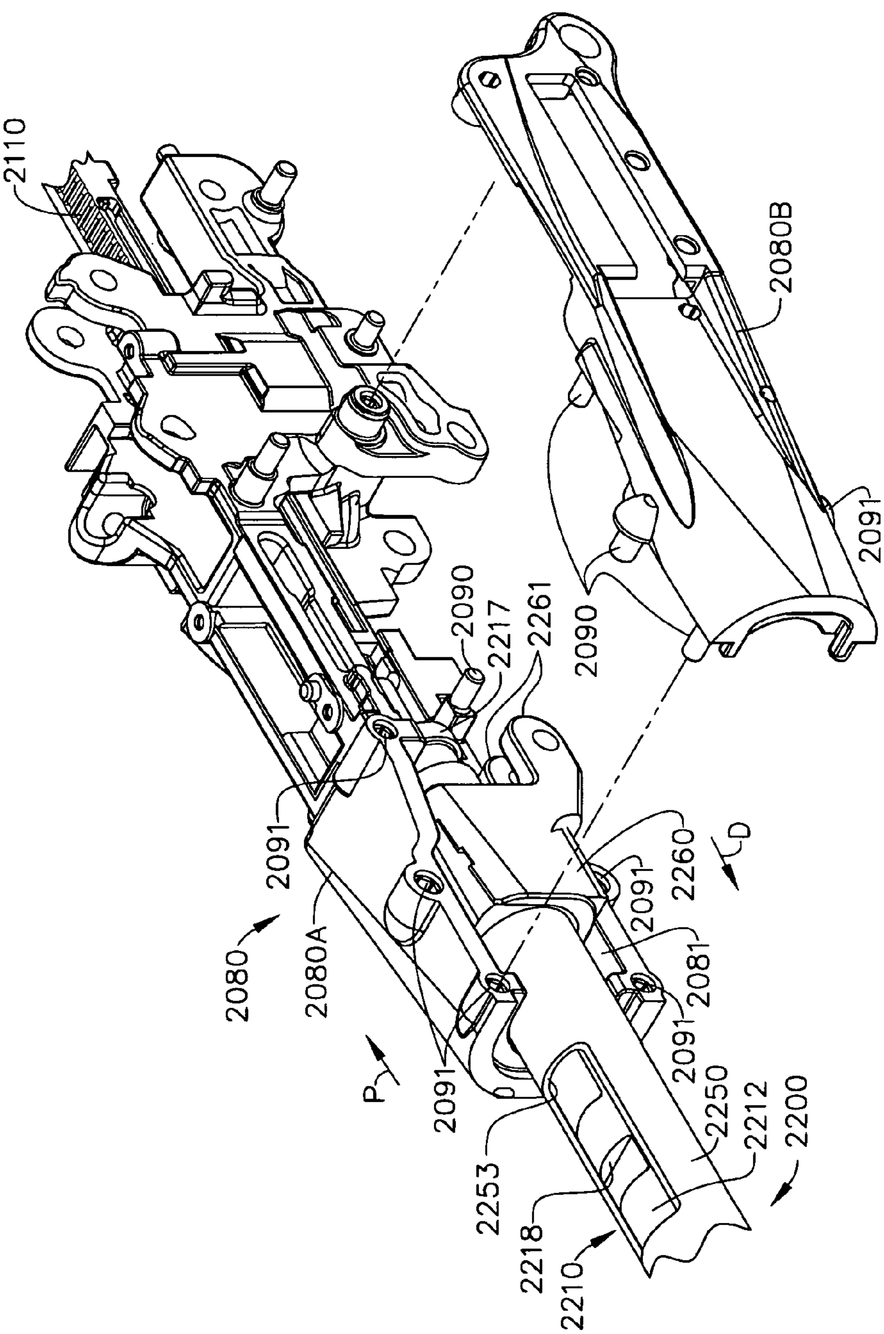

2110
2080B
2091
2090
2217
2261
2090
2091
2080
2080A
2260
D
2091
2081
2091
P
2091
2250
2212
2200
2253
2218
2210

FIG. 63

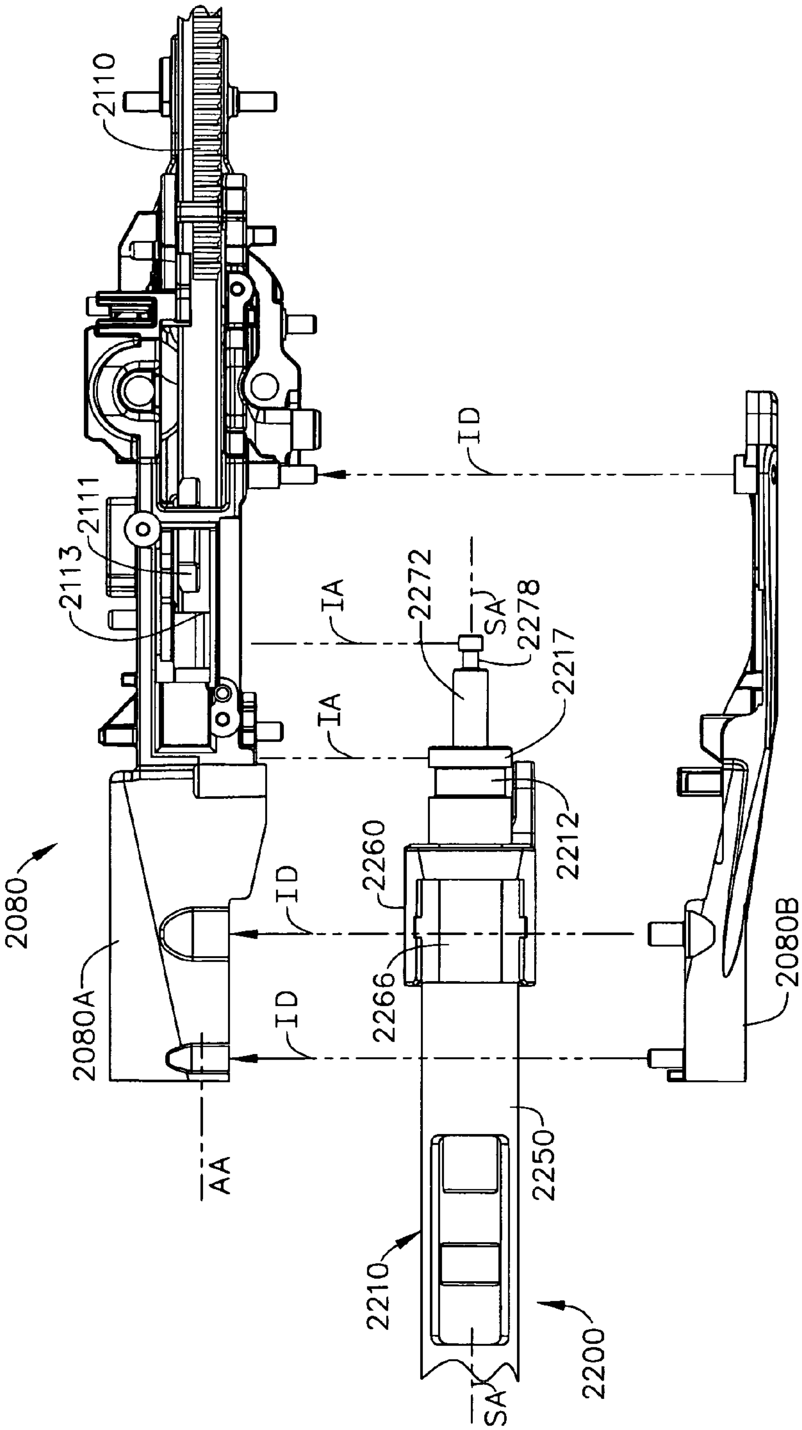

2110
2111
2113
2272
SA
2278
2217
IA
IA
ID
ID
ID
2080
2080A
2260
2266
2212
2080B
AA
2250
2210
2200
SA

FIG. 64

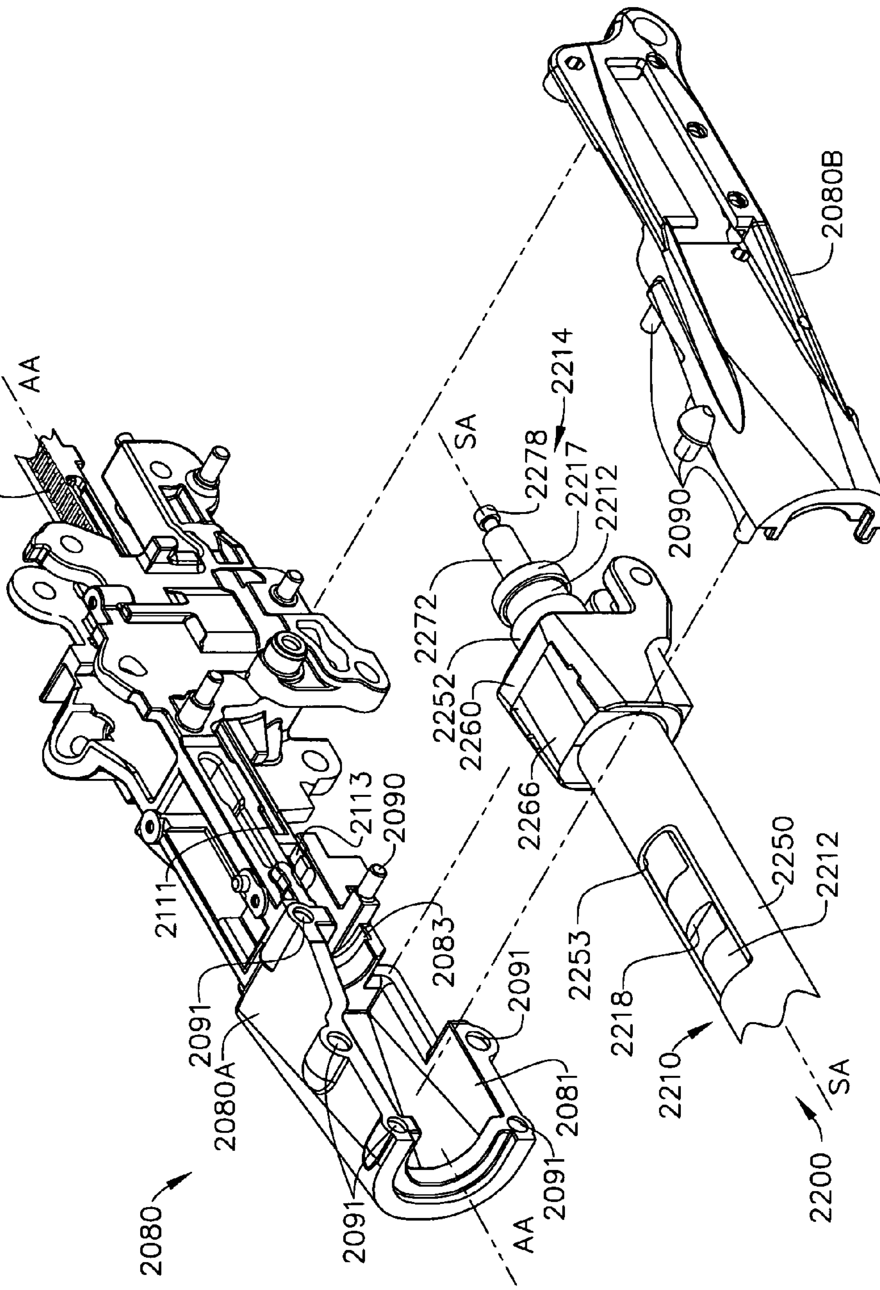
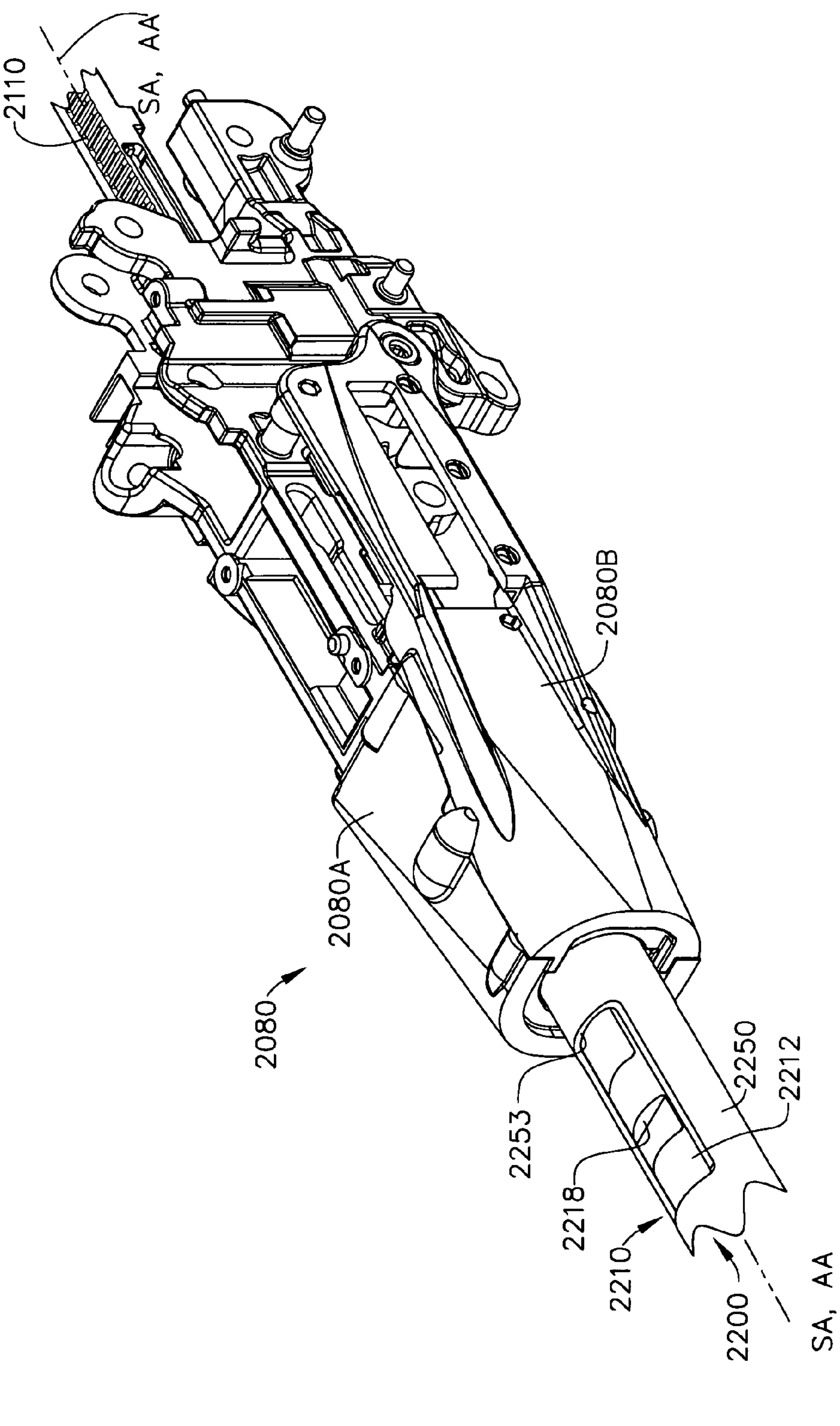

AA
2110
2214
SA
2278
2217
2212
2080B
2090
2272
2252
2260
2266
2113
2090
2111
2083
2091
2250
2212
2253
2218
2091
2091
2080A
2081
2210
SA
2080
2091
2091
AA
2200

FIG. 65



SA, AA
2110
2080B
2080A
2080
2253
2250
2212
2218
2210
2200
SA, AA


FIG. 66

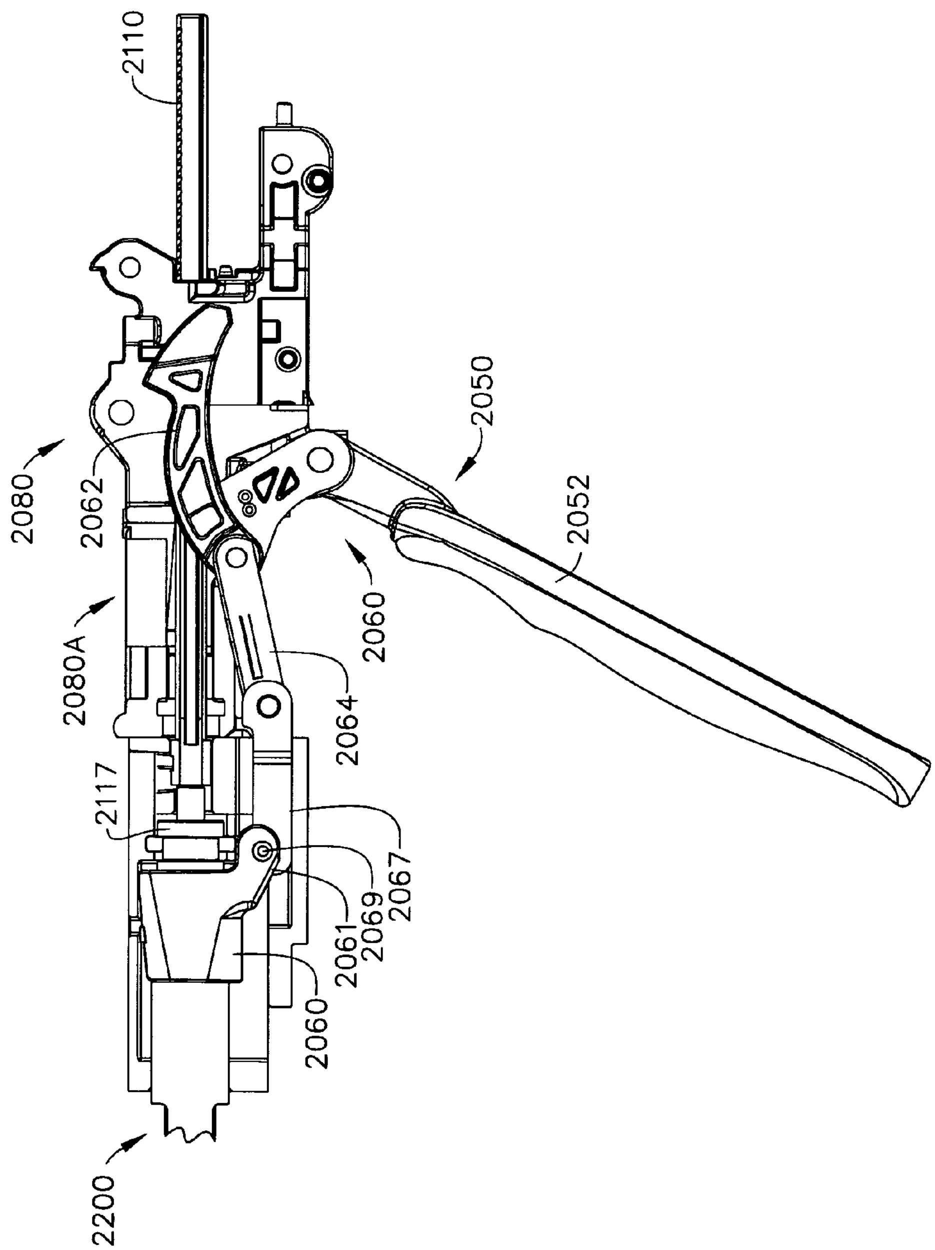

2110
2050
2052
2080
2062
2060
2080A
2064
2117
2067
2069
2061
2060
2200

FIG. 67

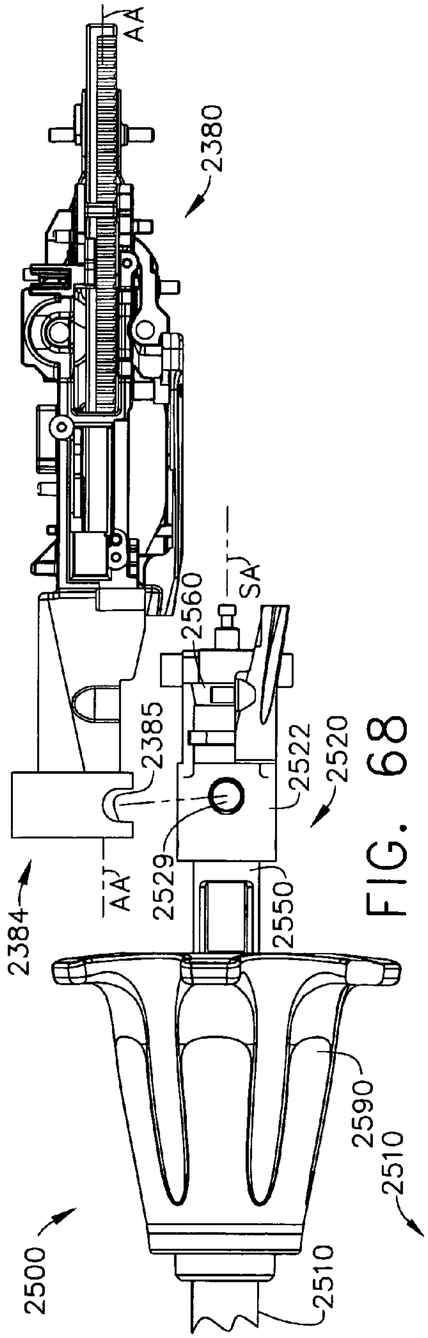

AA
2380
SA
2560
2385
2522
2520
2529
2550
AA
2384
2500
2510
2590

FIG. 68

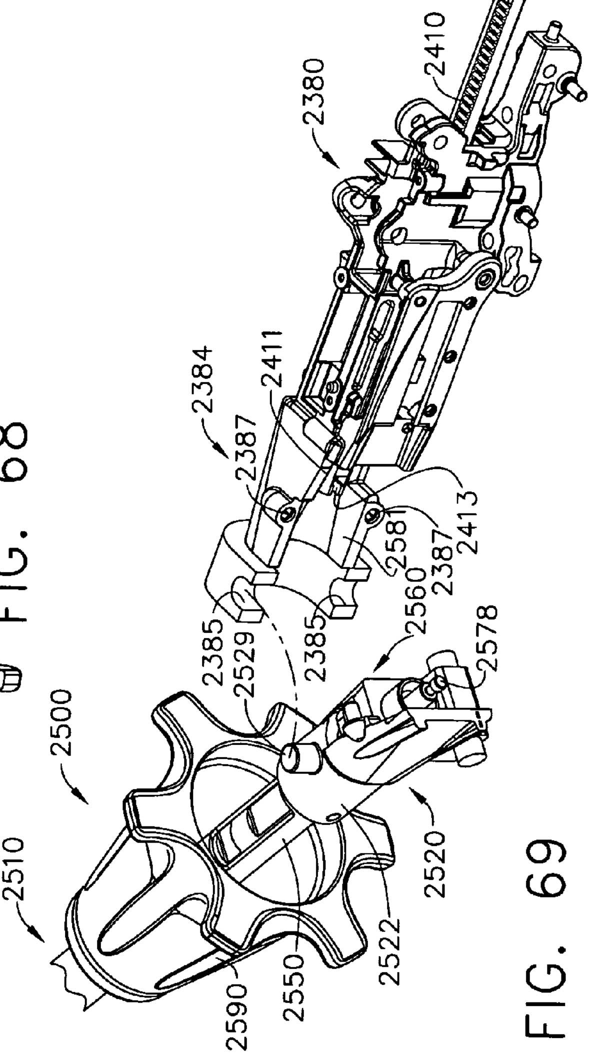

2410
2380
2384
2411
2387
2413
2581
2387
2560
2385
2385
2529
2560
2578
2500
2510
2590
2550
2522
2520

FIG. 69

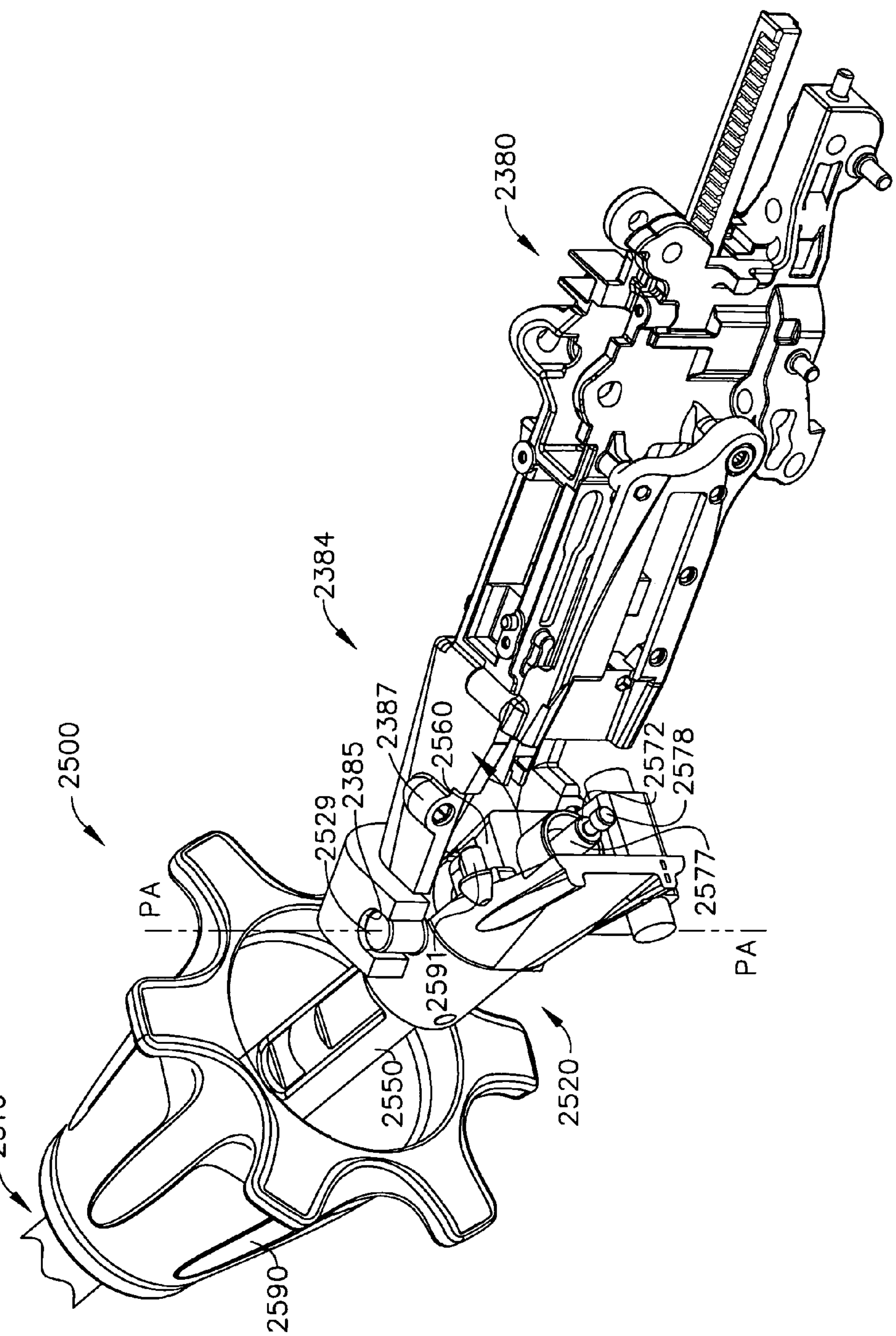

2380
2384
2500
2529
2385
2387
2560
2572
2578
2577
PA
PA
2591
2520
2550
2510
2590

FIG. 70

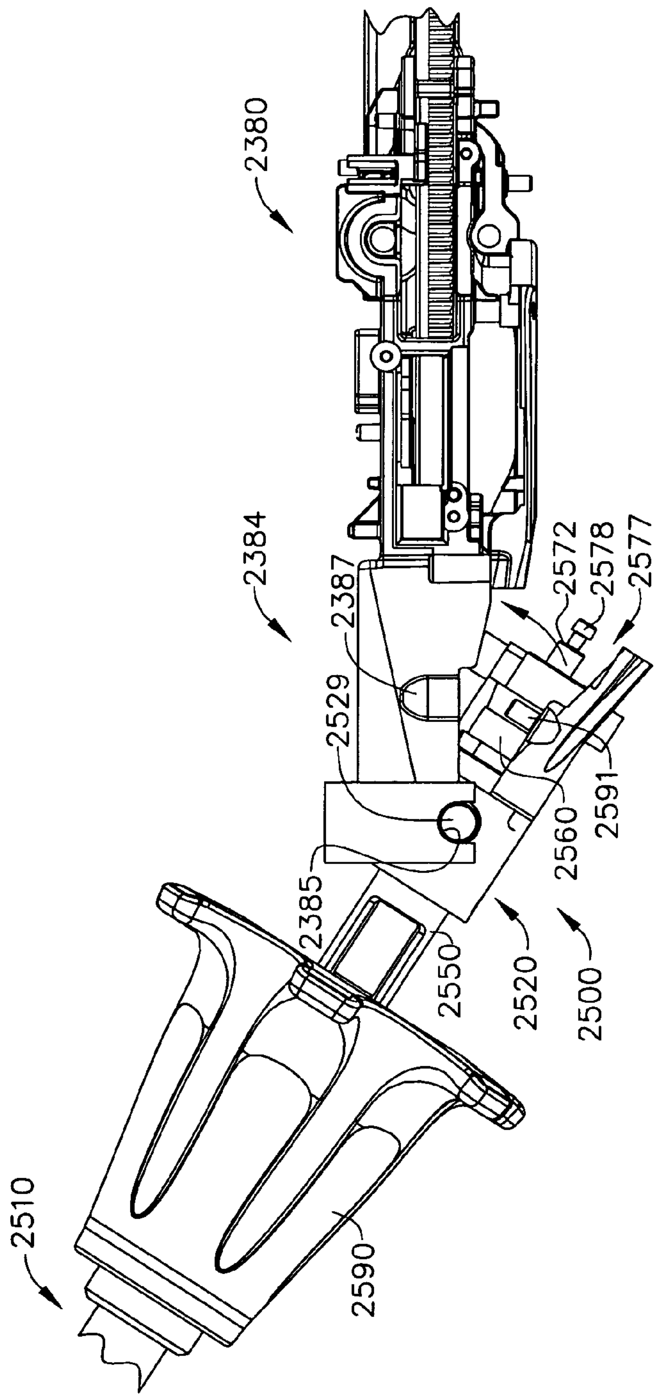

2380
2384
2387
2529
2385
2550
2520
2500
2572
2578
2577
2560
2591
2510
2590

FIG. 71

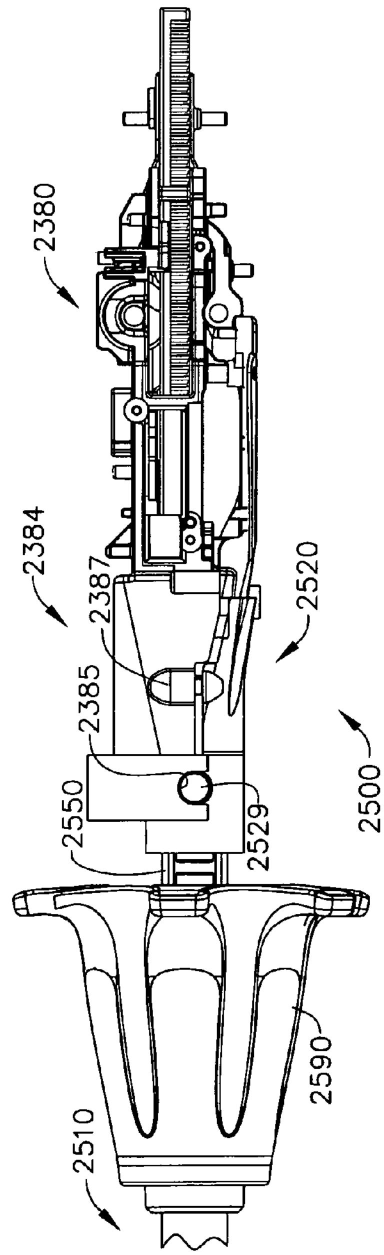

2380
2384
2387
2385
2550
2529
2520
2500
2590
2510

FIG. 72

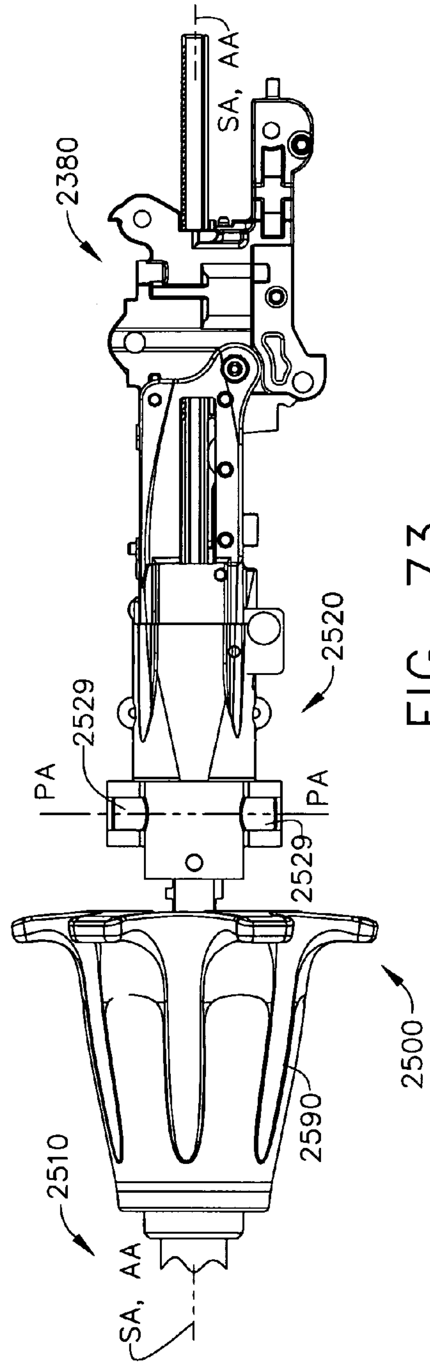

SA, AA
2380
2520
2529
PA
PA
2529
2500
2590
2510
SA, AA

FIG. 73

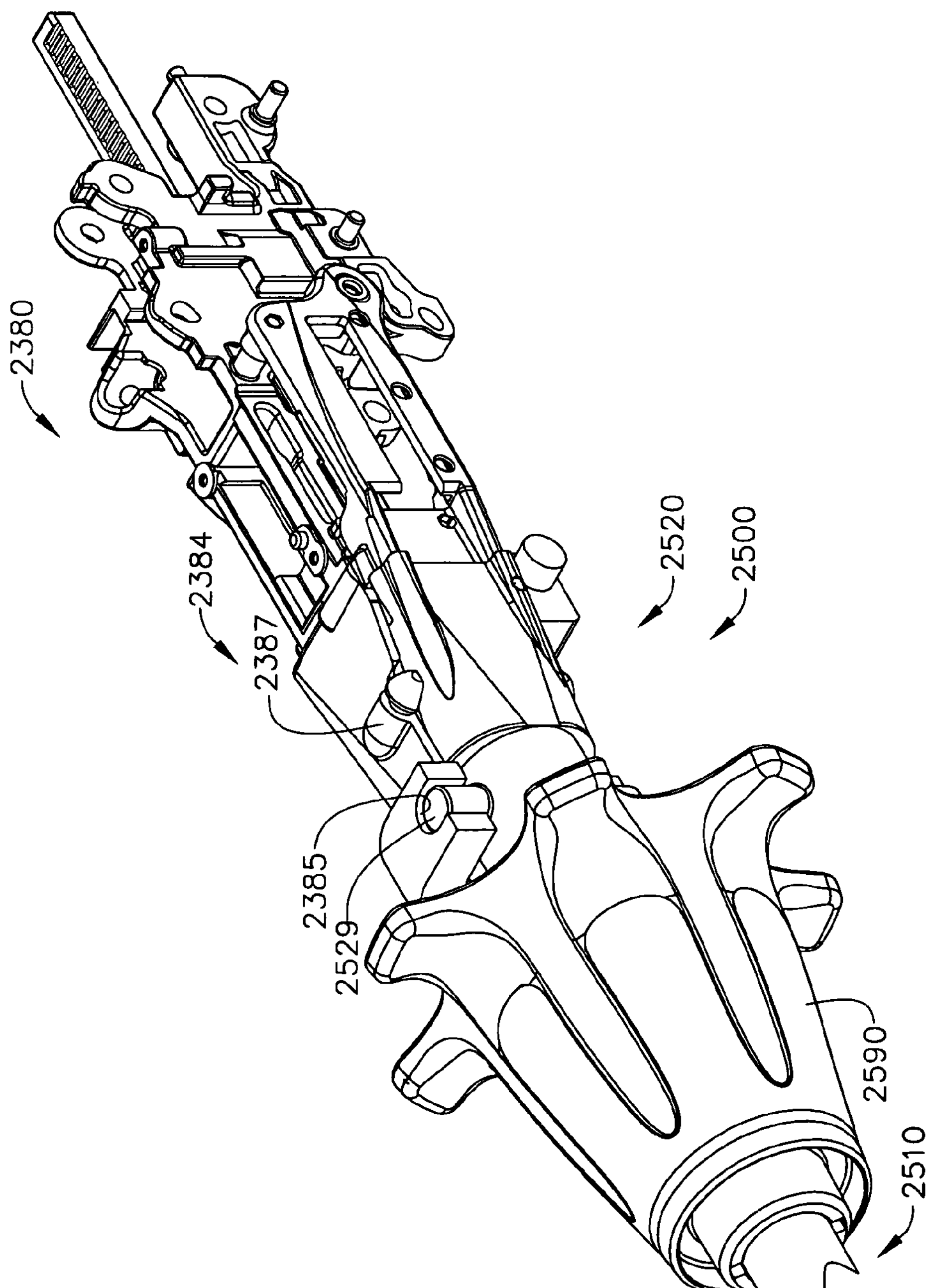
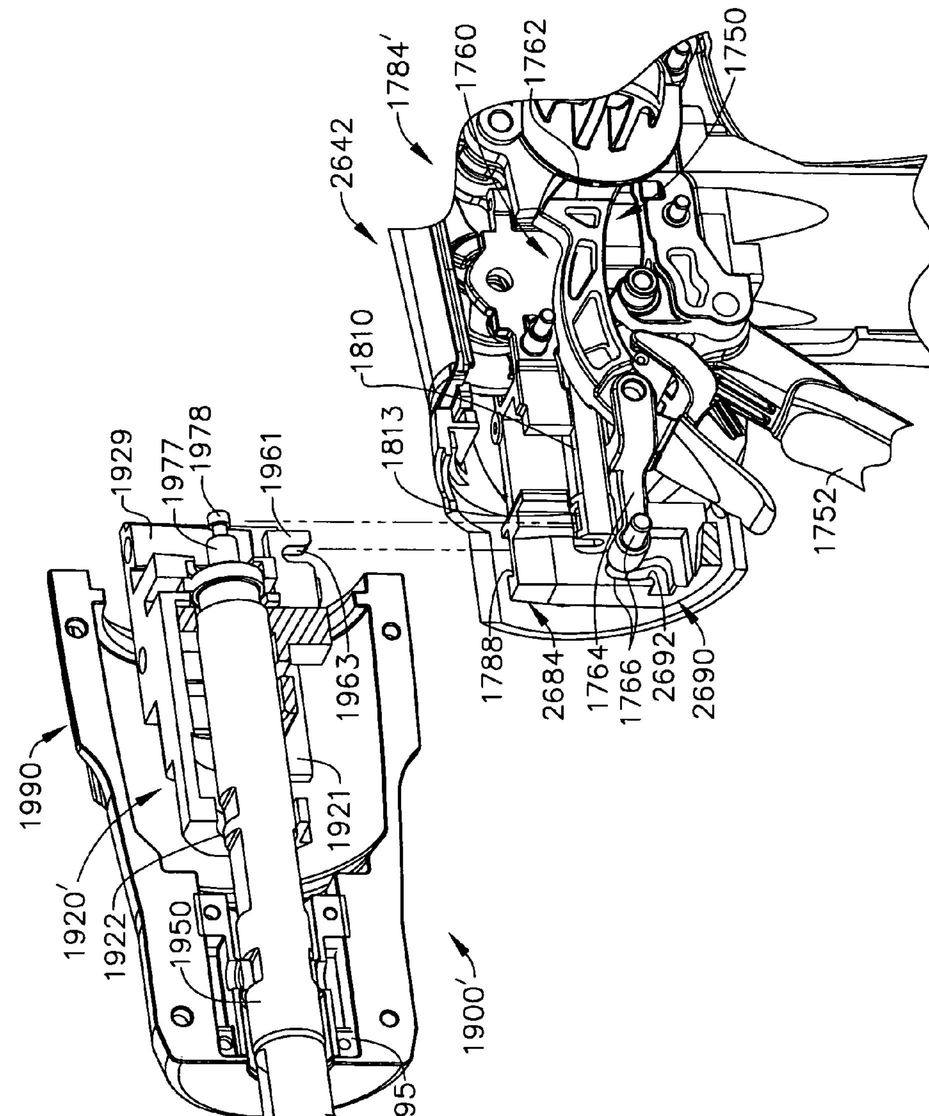
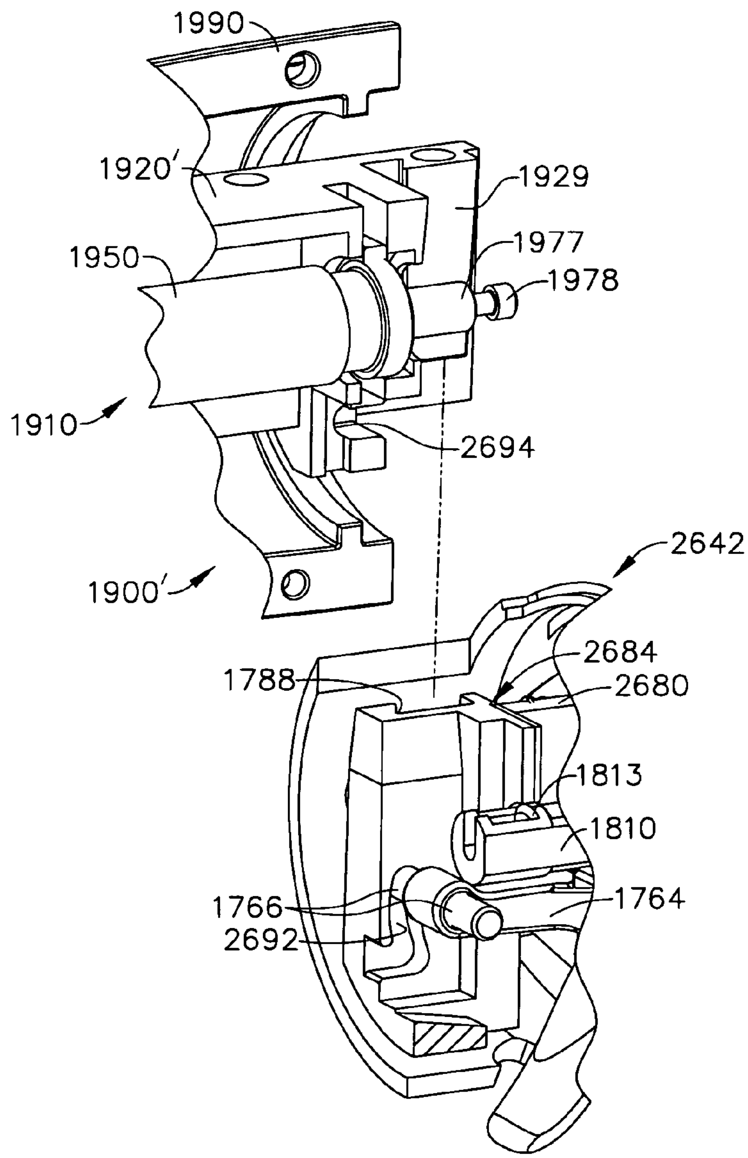



FIG. 74



2642
1784′
1760
1762
1750
1810
1813
1752
1788
2684
1764
1766
2692
2690
1929
1977
1978
1961
1963
1921
1990
1920′
1922
1950
1900′
1995
1910


FIG. 75



1990
1920′
1929
1977
1950
1978
1910
2694
2642
1900′
2684
1788
2680
1813
1810
1766
1764
2692


FIG. 76

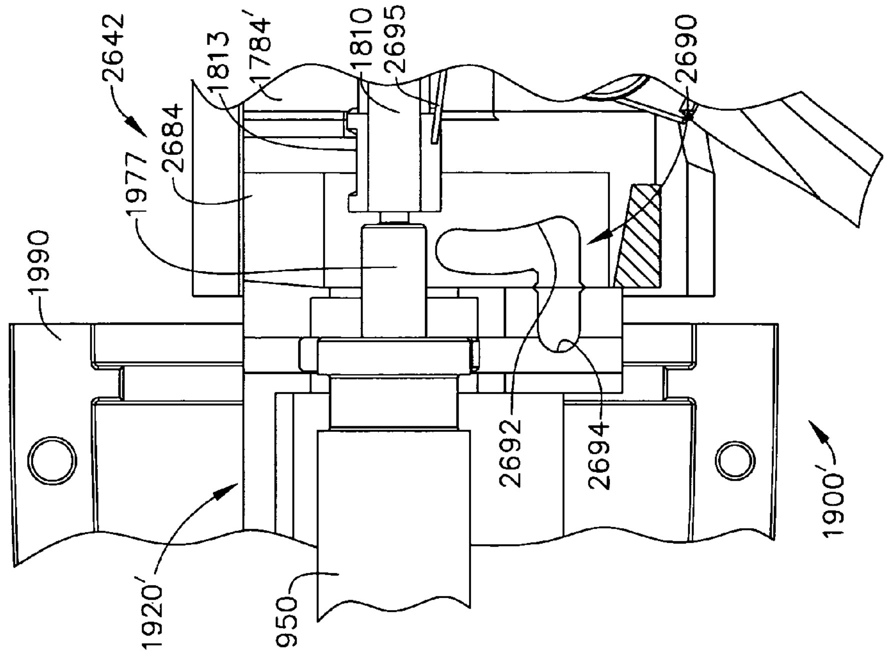

2642
1813
1784′
1810
2695
2690
2684
1977
1990
2692
2694
1900′
1920′
1950

FIG. 78

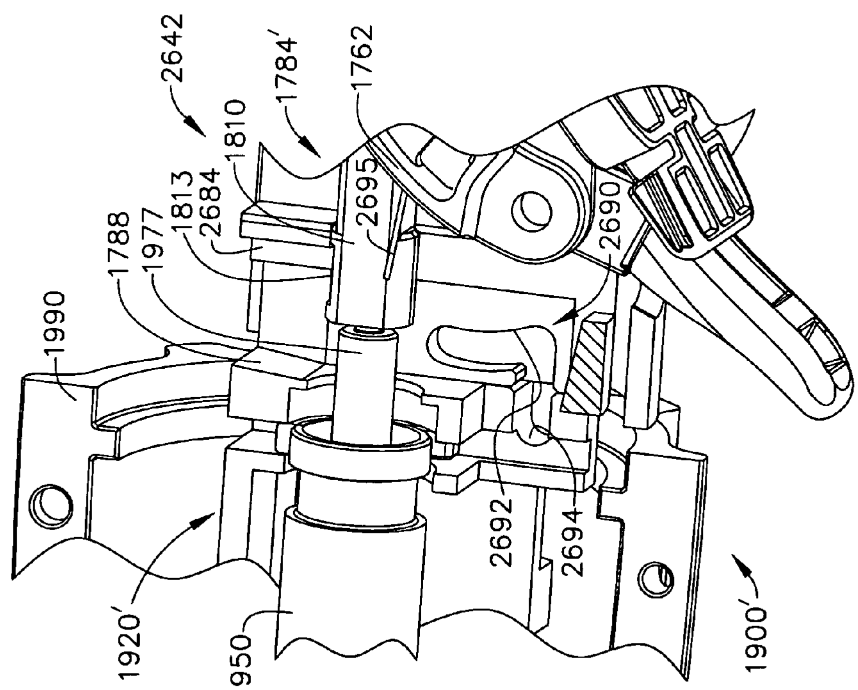

2642
1784′
1762
1810
2695
1813
2684
1977
1788
1990
2690
2692
2694
1920′
1950
1900′

FIG. 77

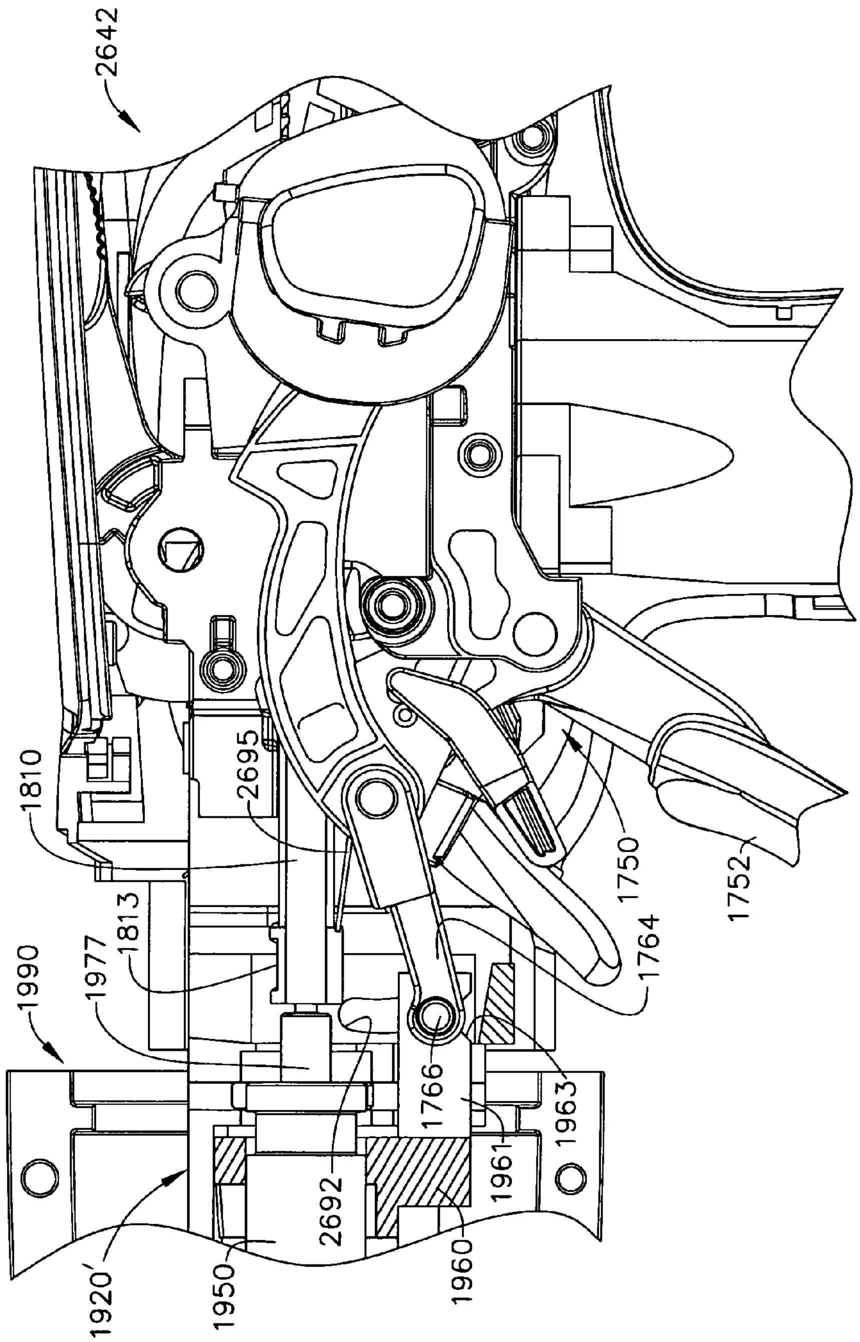

2642
1810
2695
1813
1977
1990
1750
1752
1764
1766
1963
1961
2692
1920'
1950
1960

FIG. 79

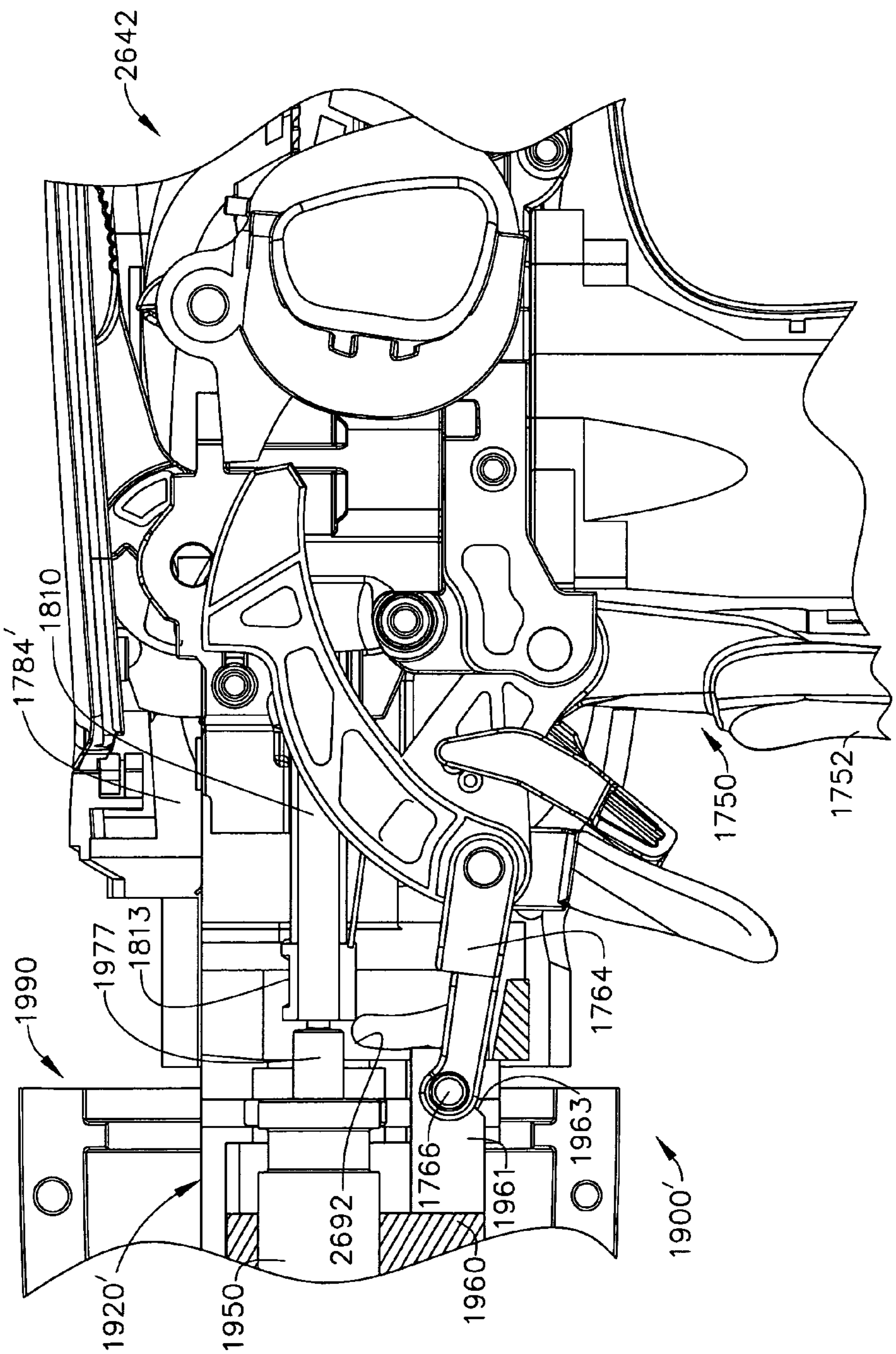

2642
1810
1784′
1977
1813
1990
1764
1750
1752
1766
1963
1961
2692
1920′
1950
1960
1900′

FIG. 80

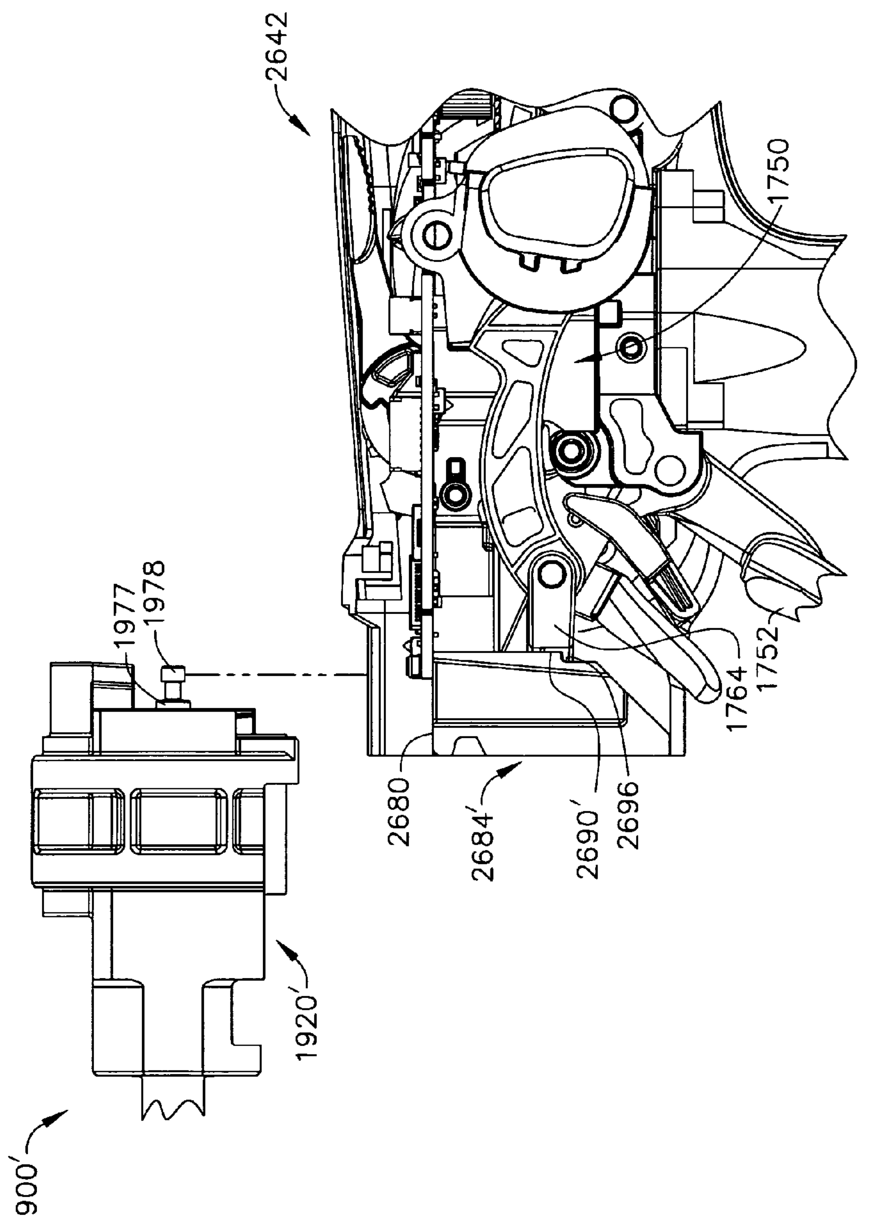



FIG. 81

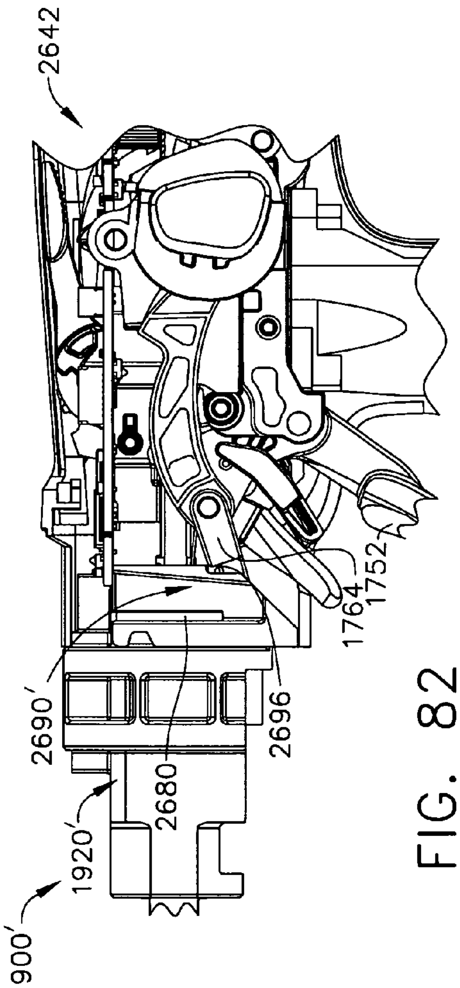

2642
1900'
1920'
2690'
2680
2696
1764
1752

FIG. 82

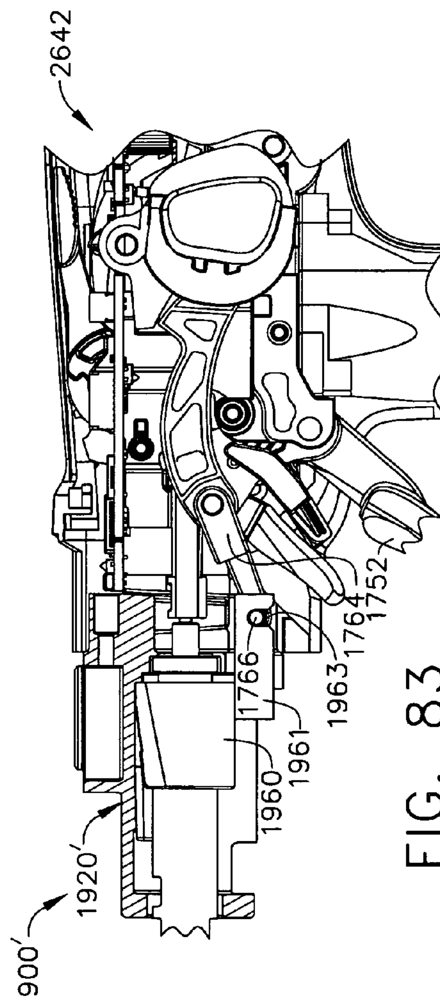

2642
1900'
1920'
1960
1961
1766
1963
1764
1752

FIG. 83

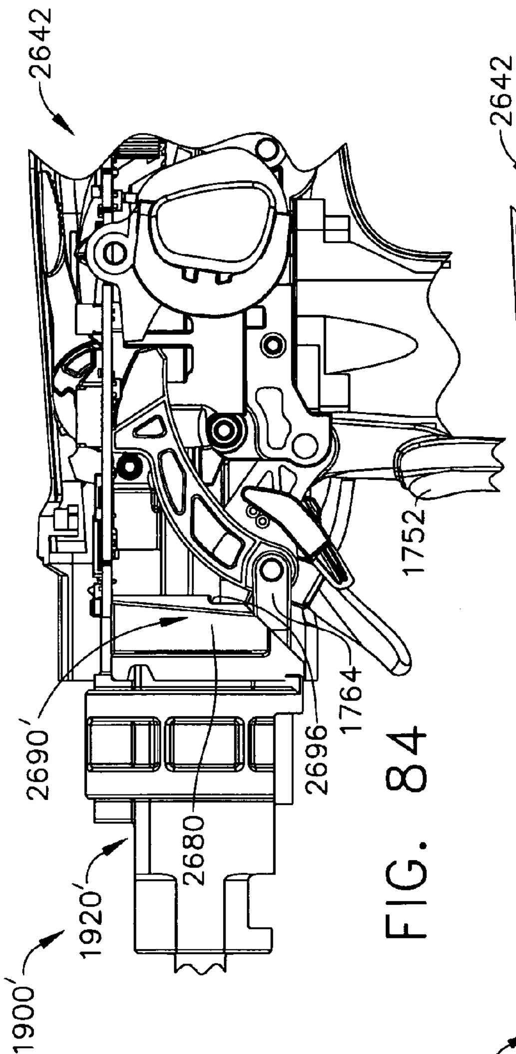

2642
1752
1764
2696
2690'
2680
1920'
1900'

FIG. 84

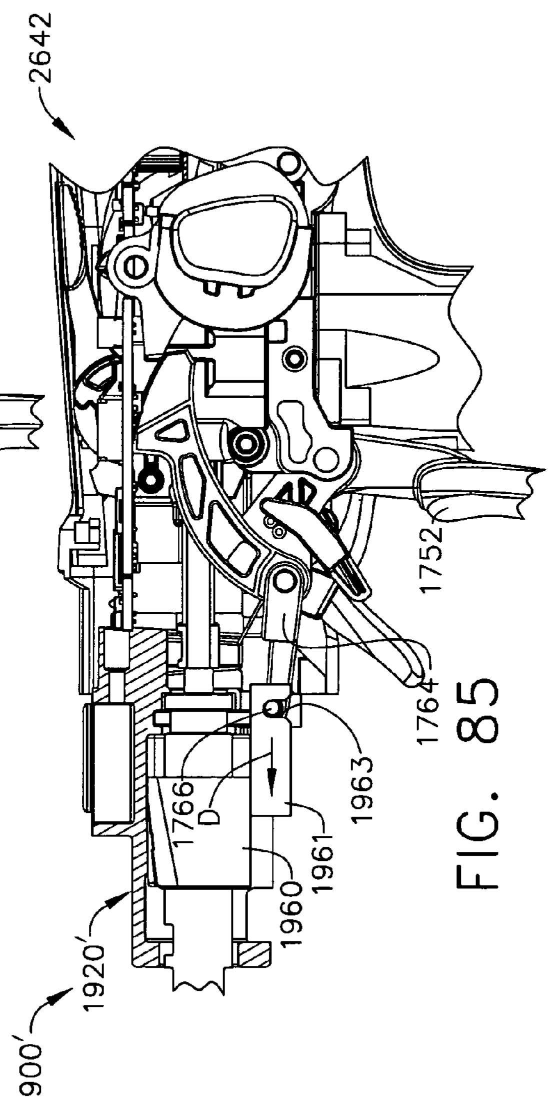

2642
1752
1764
1963
1766
D
1961
1960
1920'
1900'

FIG. 85

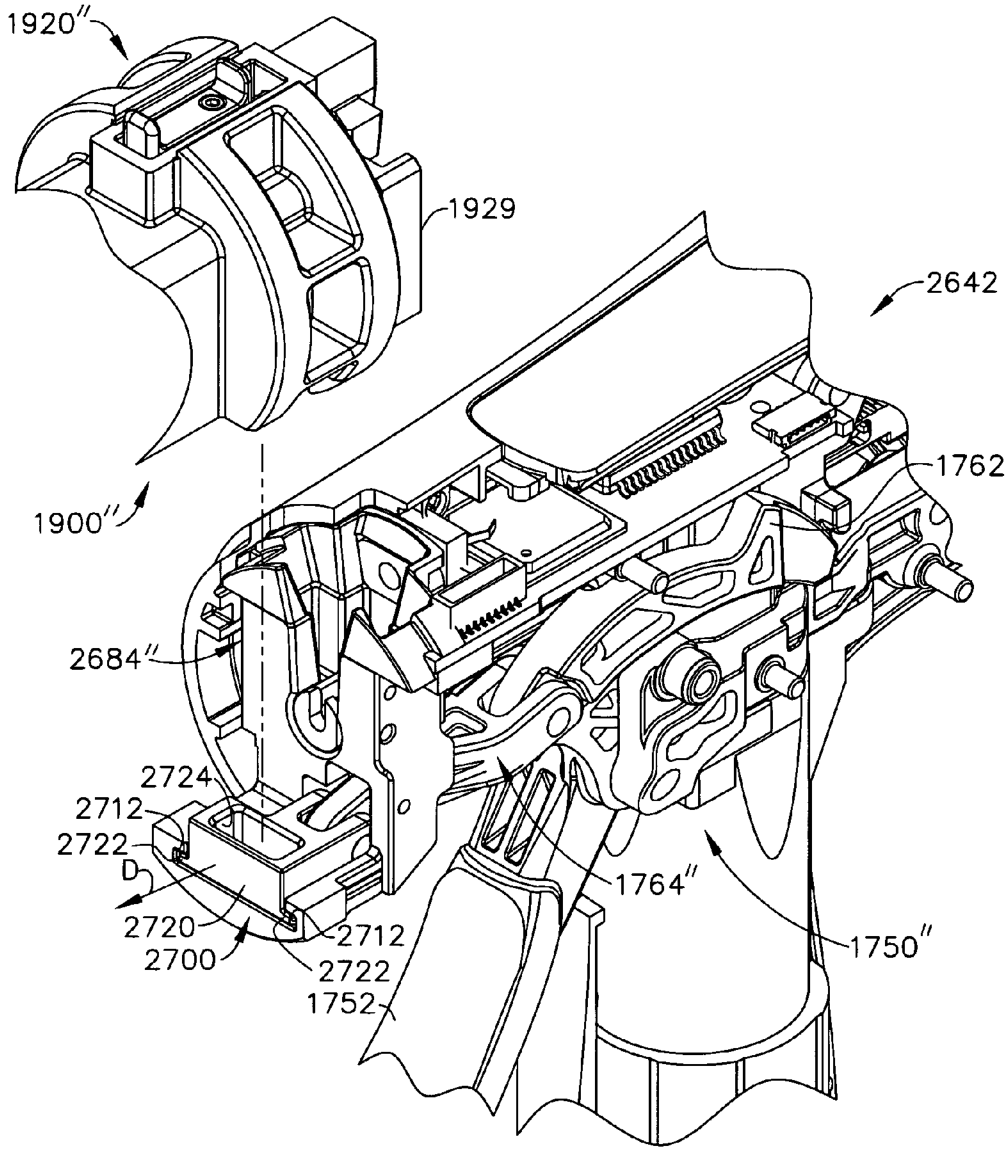

1920″
1929
2642
1762
1900″
2684″
2724
2712
2722
D
2720
2700
2712
2722
1752
1764″
1750″

FIG. 86

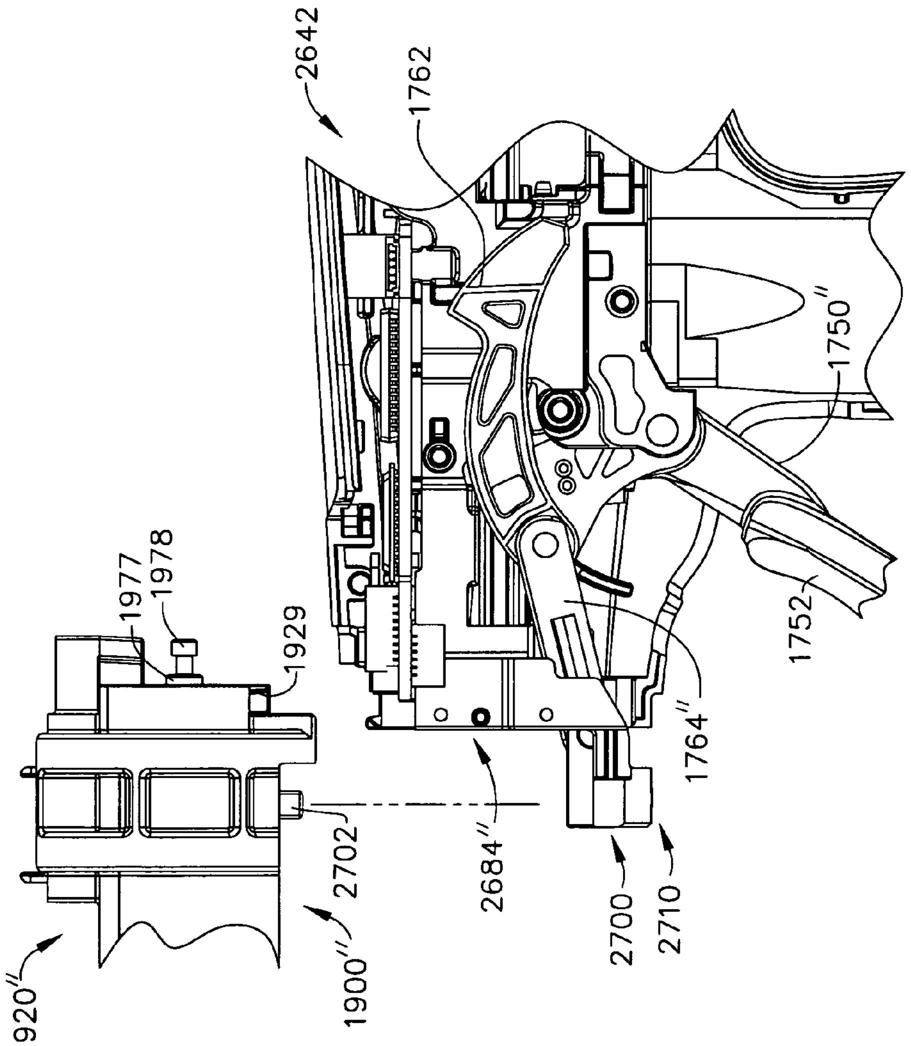

2642
1762
1750''
1752
1764''
1977
1978
1929
2684''
2702
2700
2710
1900''
1920''

FIG. 87

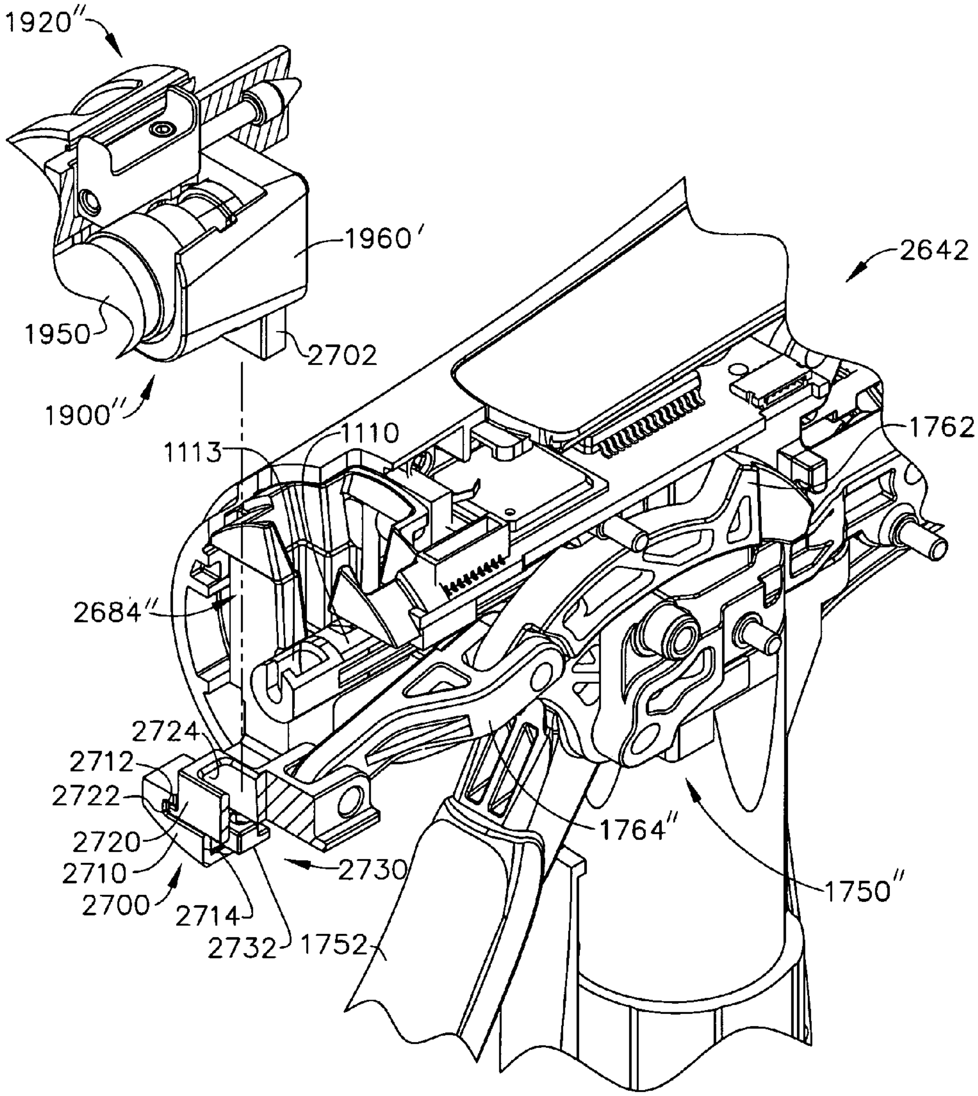

1920″
1960′
2642
1950
2702
1900″
1762
1110
1113
2684″
2724
2712
2722
2720
2710
2700
2714
2732
1752
2730
1764″
1750″

FIG. 88

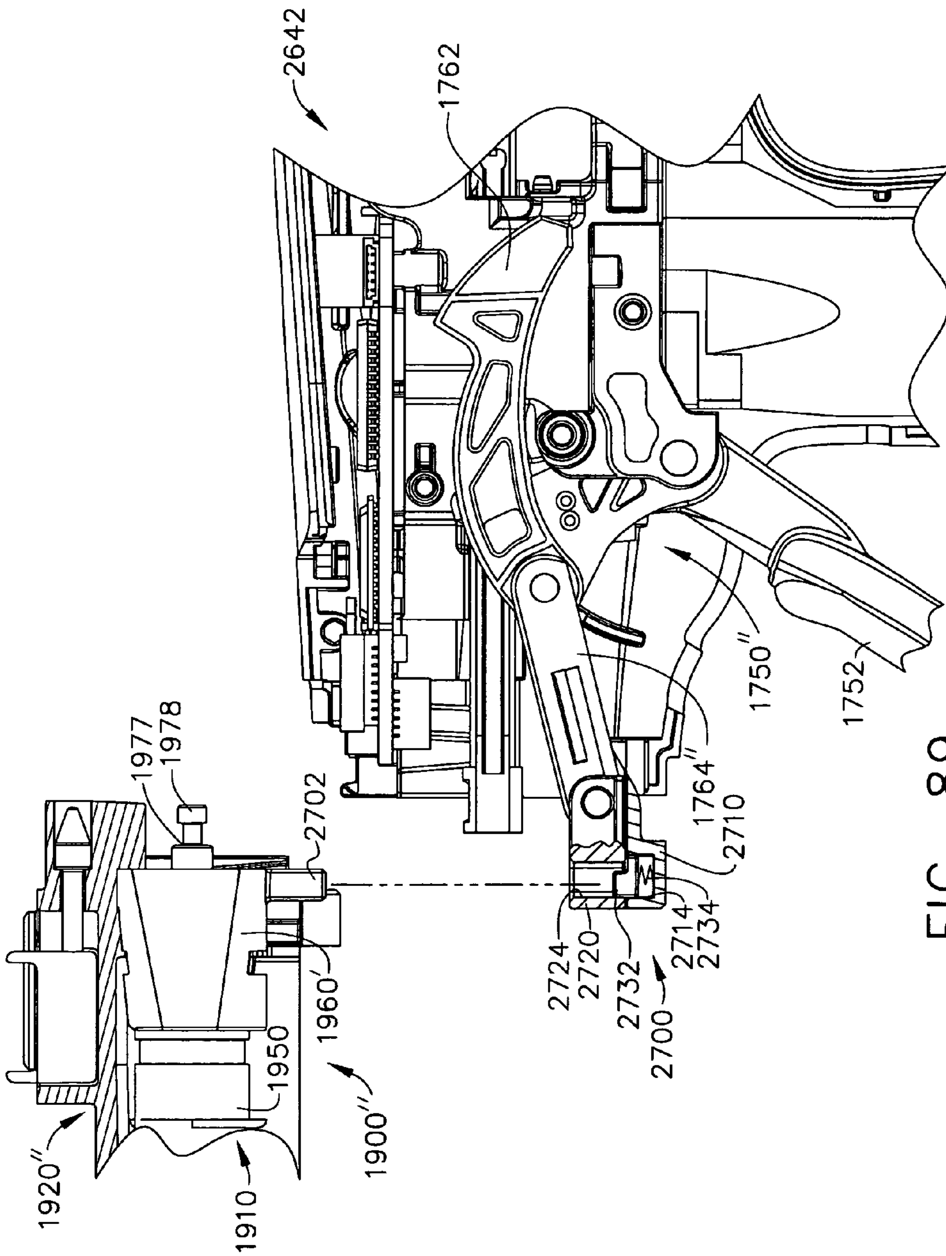

2642
1762
1750''
1752
1764''
2710
2714
2734
2700
2732
2720
2724
1977
1978
2702
1960'
1950
1900''
1910
1920''

FIG. 89

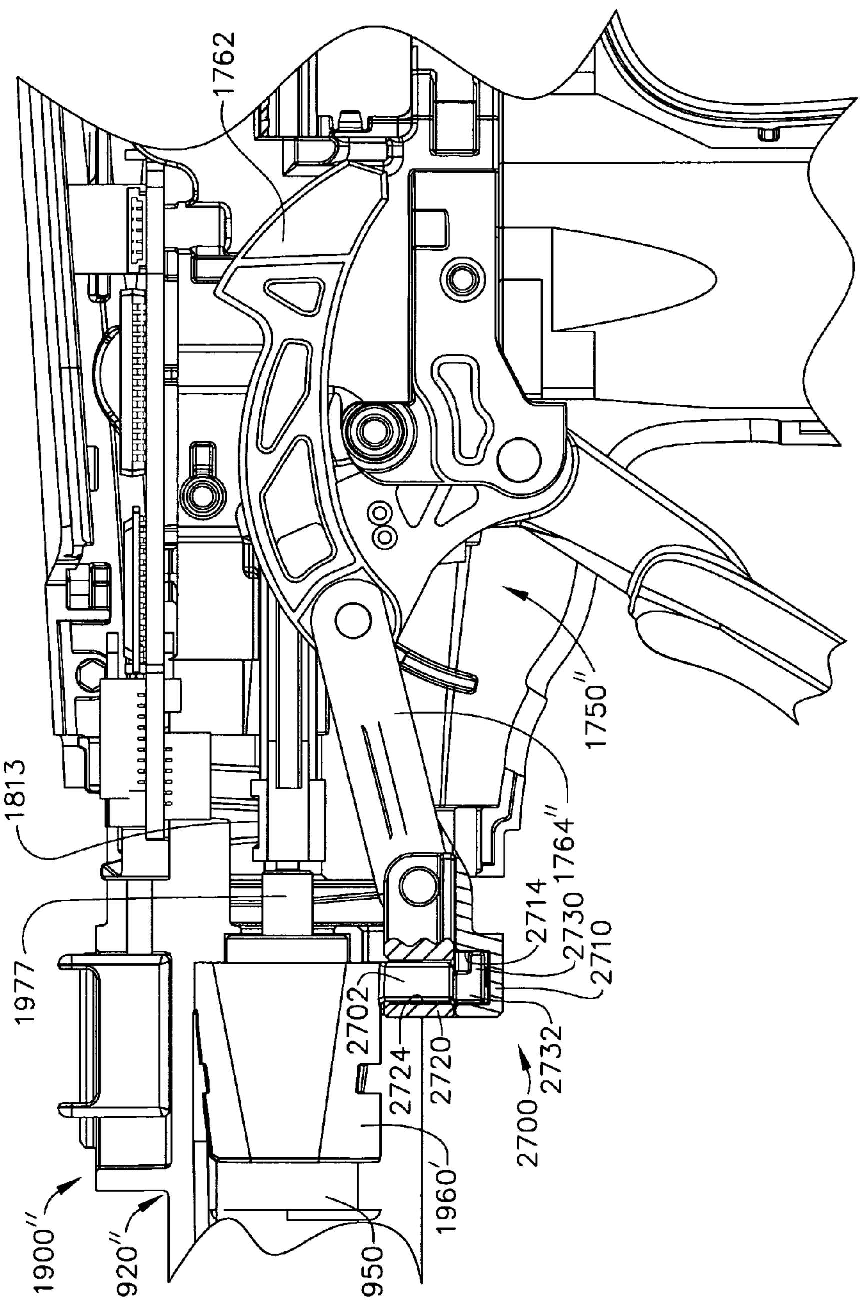

1762
1813
1977
1900''
1920''
1950
1960'
2700
2732
2720
2724
2702
2710
2730
2714
1764''
1750''

FIG. 90

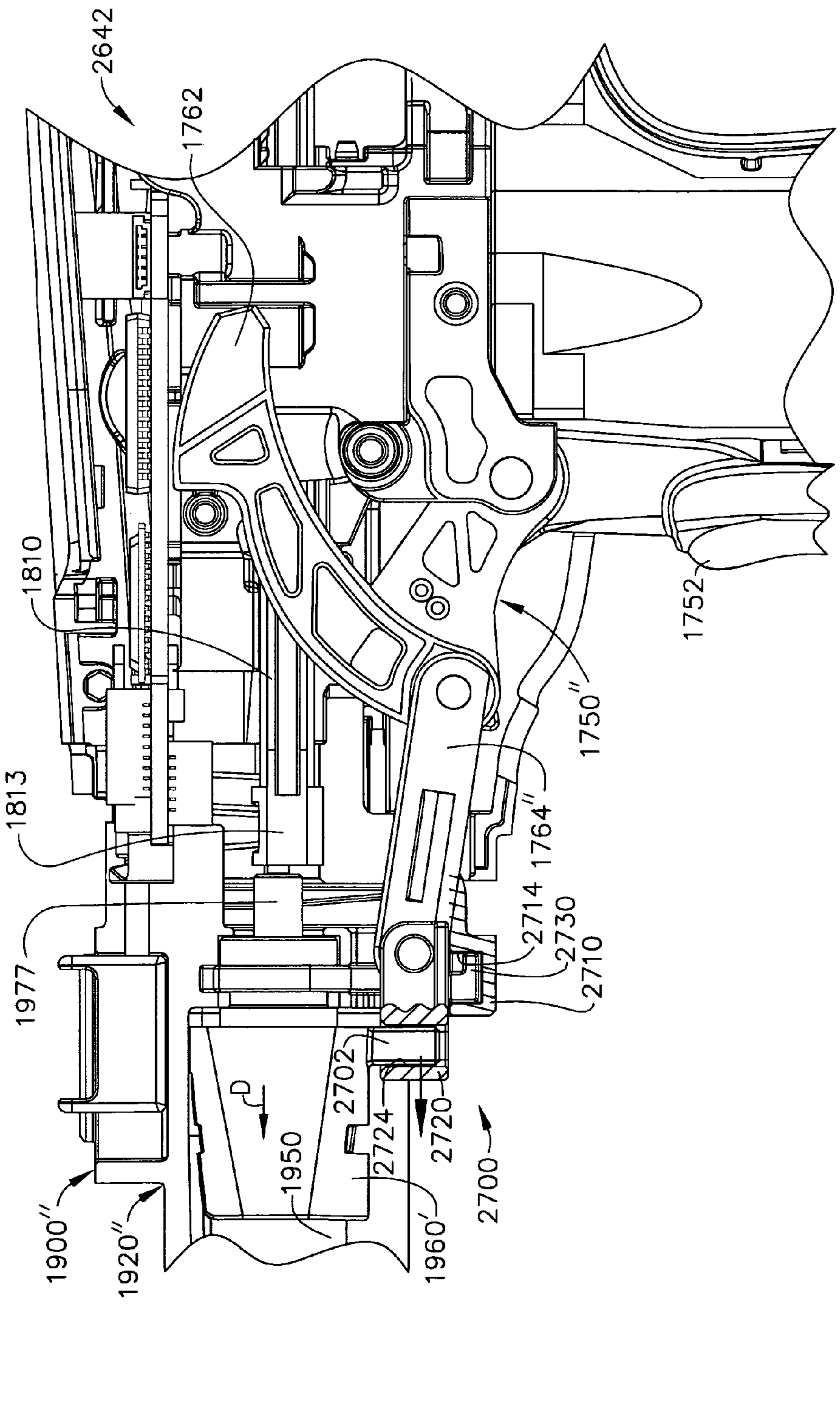

2642
1762
1810
1813
1977
1752
1750''
1764''
2714
2730
2710
2702
2724
2720
D
1950
1960'
2700
1900''
1920''

FIG. 91

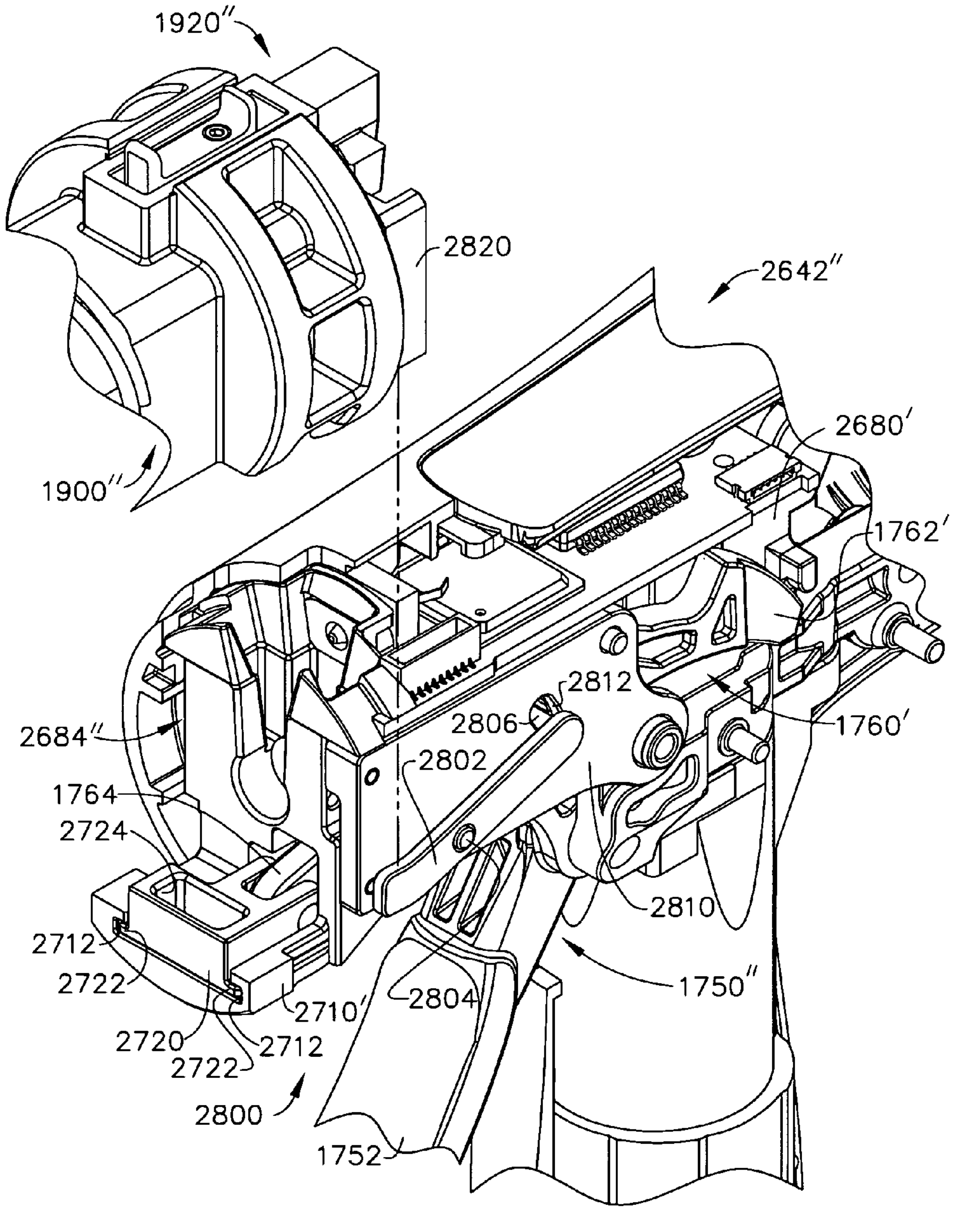

1920″
2820
2642″
2680′
1762′
1900″
2812
2806
1760′
2684″
2802
1764
2724
2810
2712
2722
2710′
2804
1750″
2720
2712
2722
2800
1752

FIG. 92

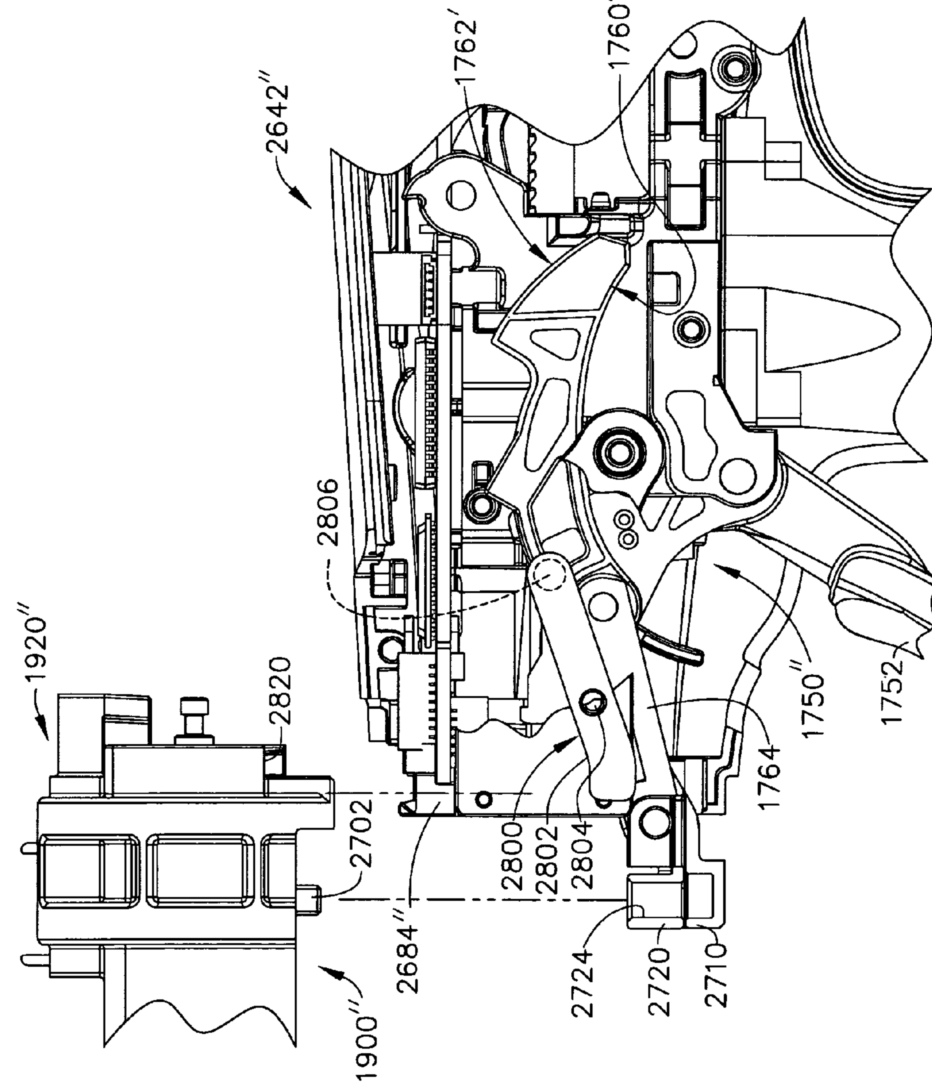

2642''
1762'
1760'
2806
1920''
2820
2702
2684''
1900''
2800
2802
2804
2724
2720
2710
1764
1750''
1752

FIG. 93

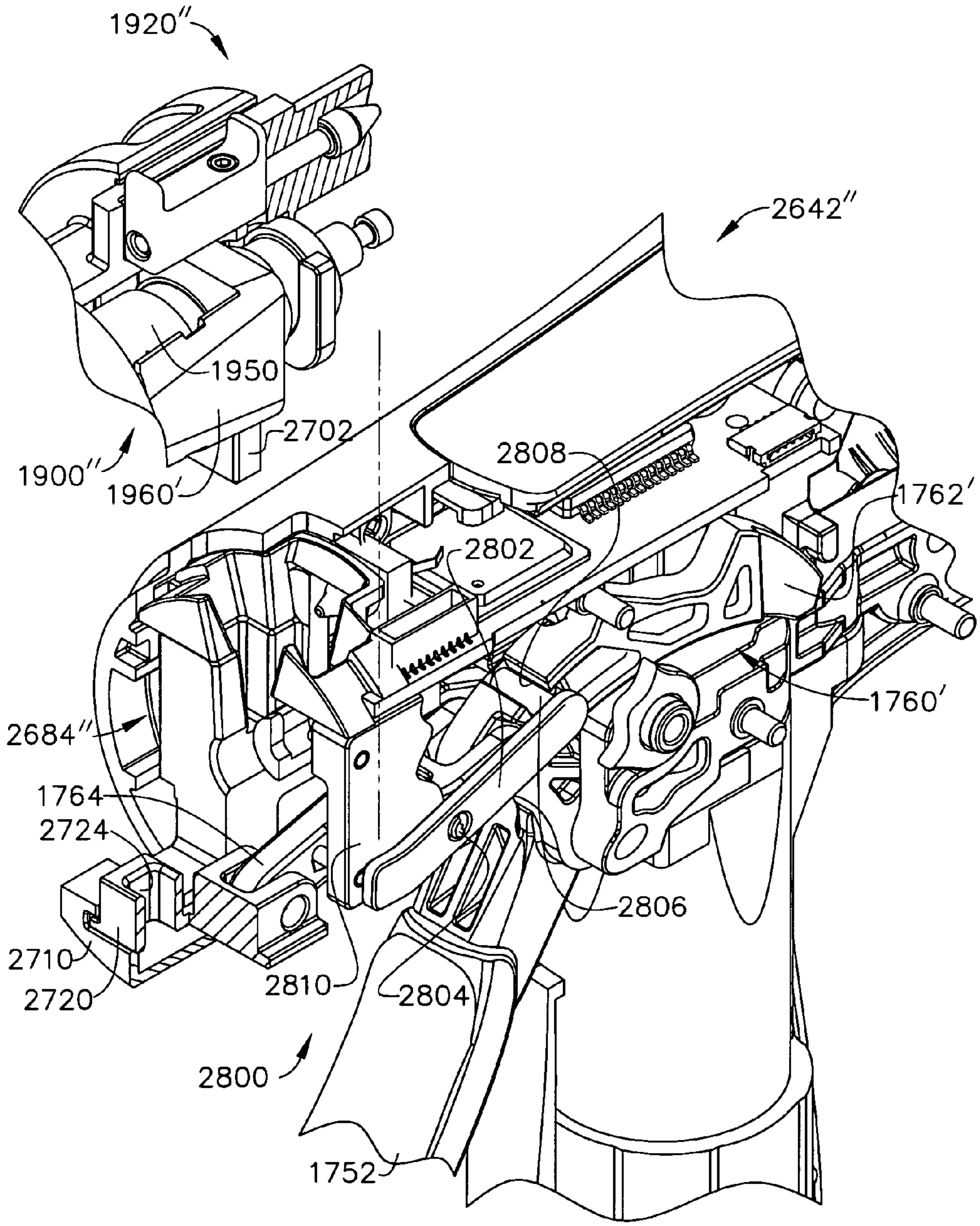

1920″
2642″
1950
2702
1900″
1960′
2808
1762′
2802
1760′
2684″
1764
2724
2806
2710
2720
2810
2804
2800
1752

FIG. 94

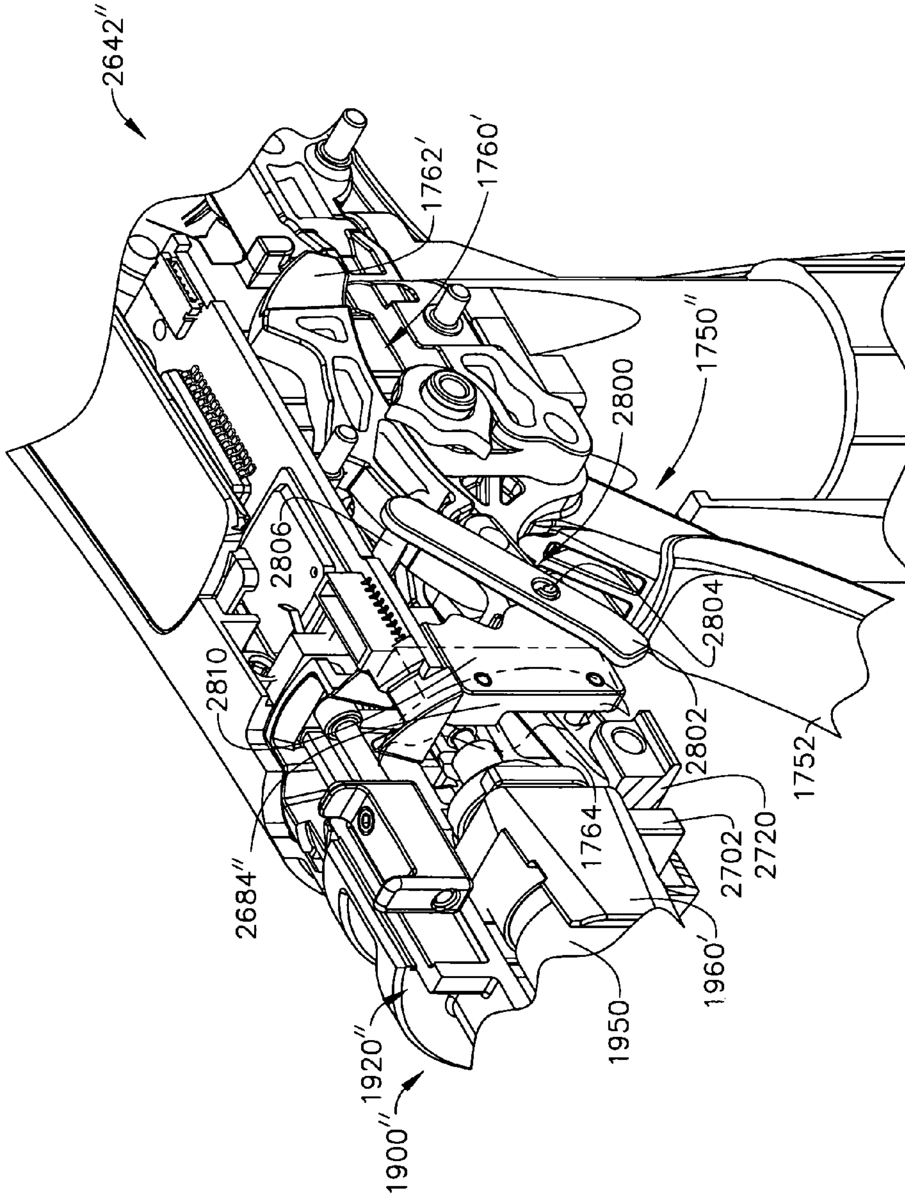

2642''
1762'
1760'
1750''
2800
2806
2804
2810
2802
1752
2684''
1764
2702
2720
1960'
1950
1920''
1900''

FIG. 95

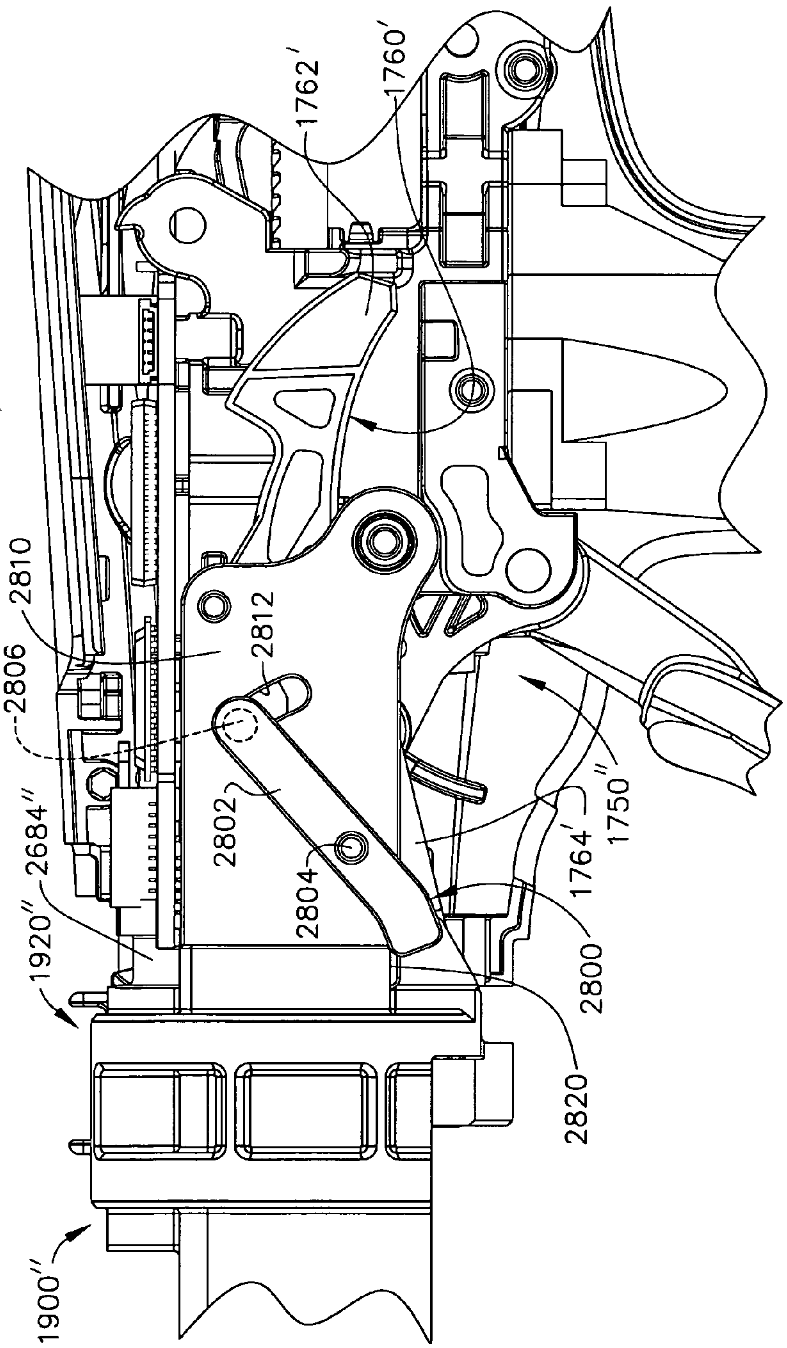

1762′
1760′
2642″
2810
2812
2806
2802
2684″
1920″
2804
1764′
1750″
2800
2820
1900″

FIG. 96

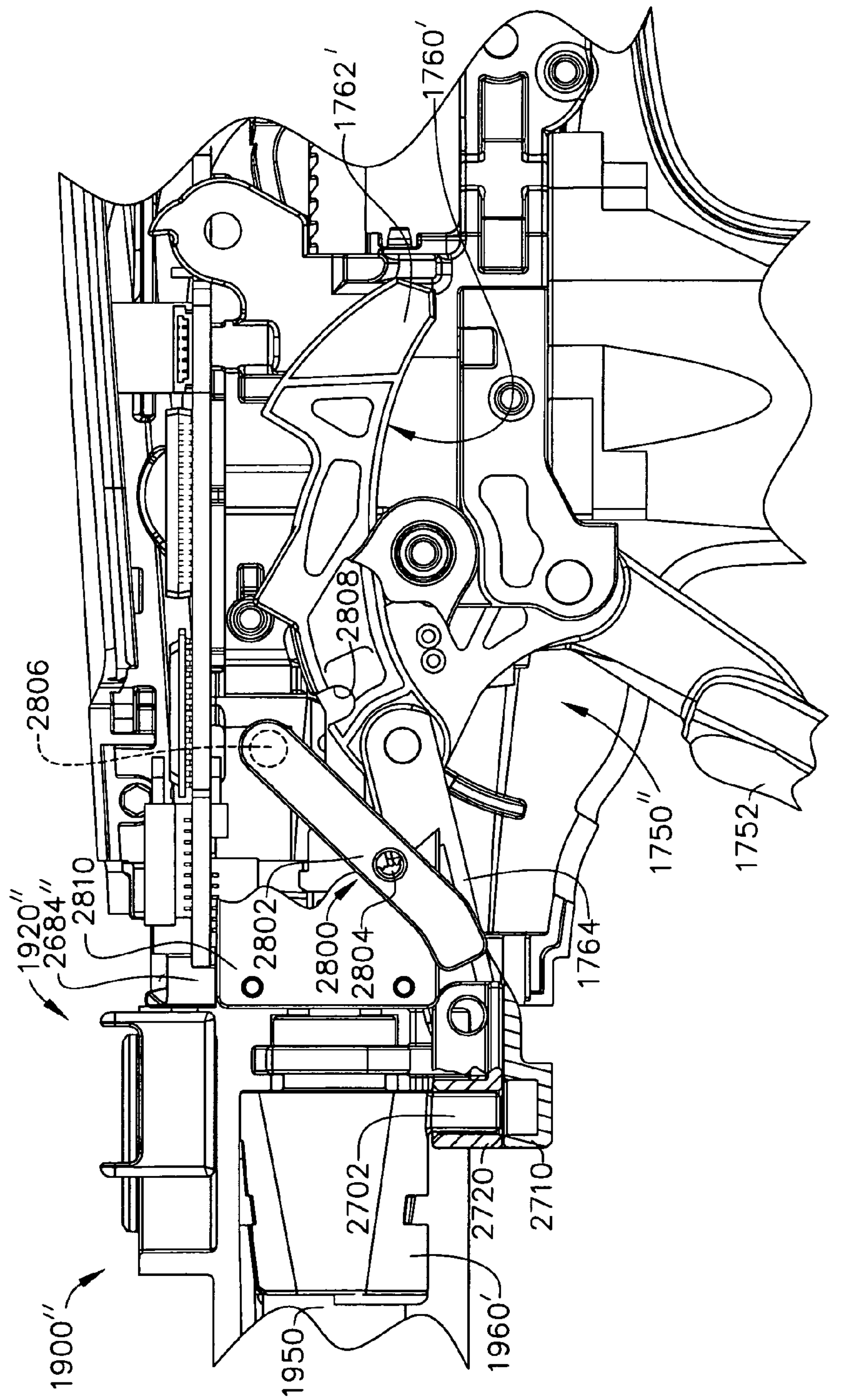

1762'
1760'
2806
1920''
2684''
2810
2802
2800
2804
2808
1750''
1752
1764
2702
2720
2710
1900''
1950
1960'

FIG. 97

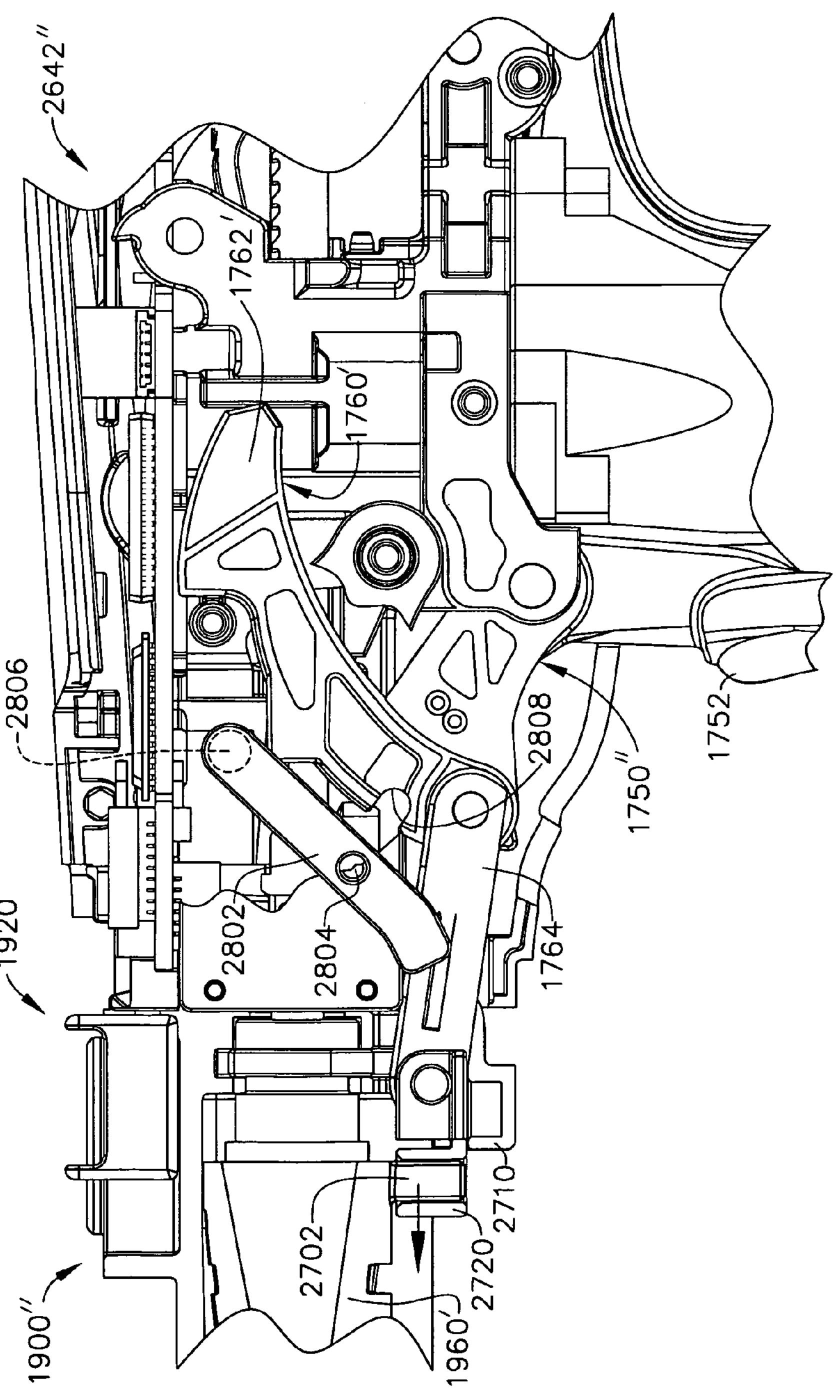

2642″
1762′
1760′
2806
2808
1750″
1752
1920″
2802
2804
1764
2710
2702
2720
1900″
1960′

FIG. 98

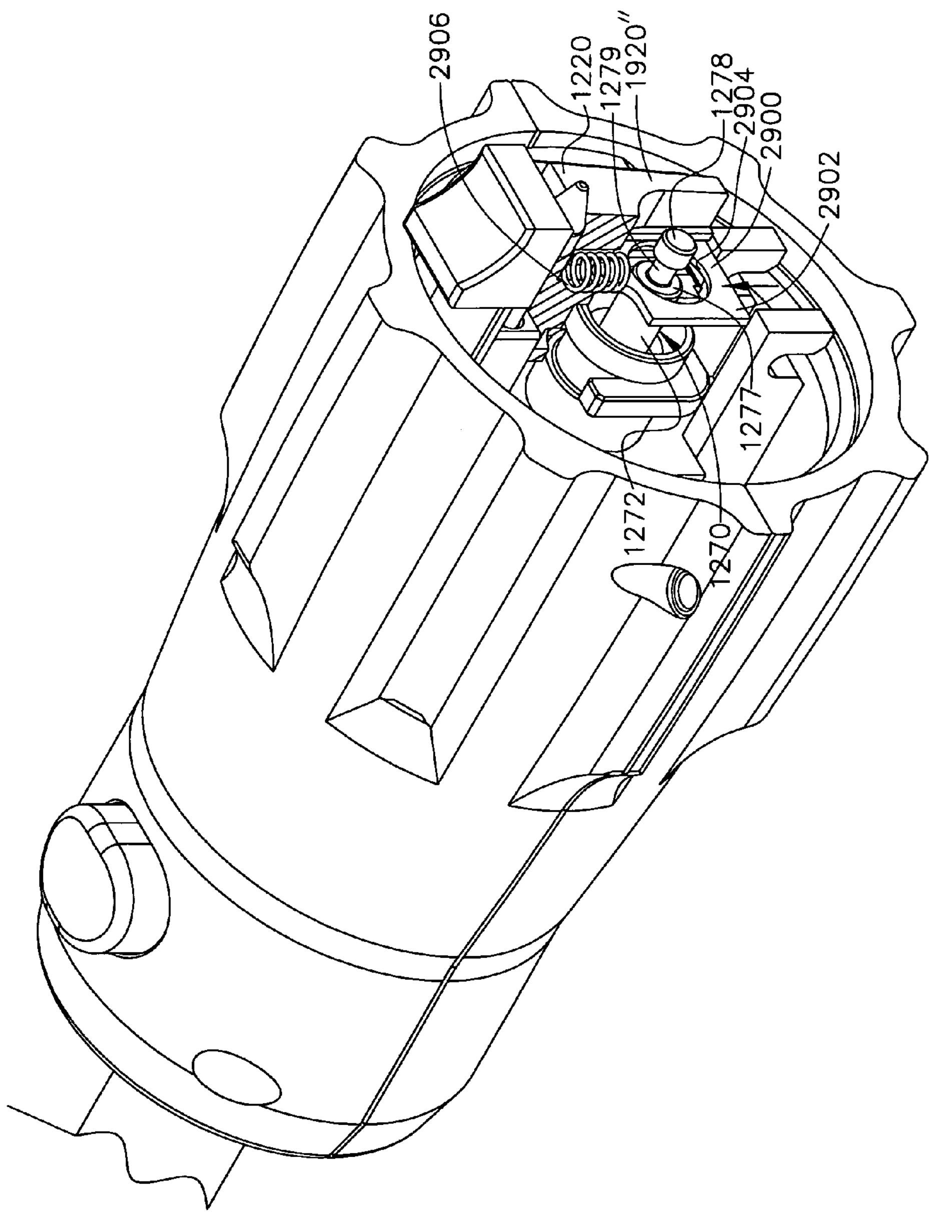



FIG. 99

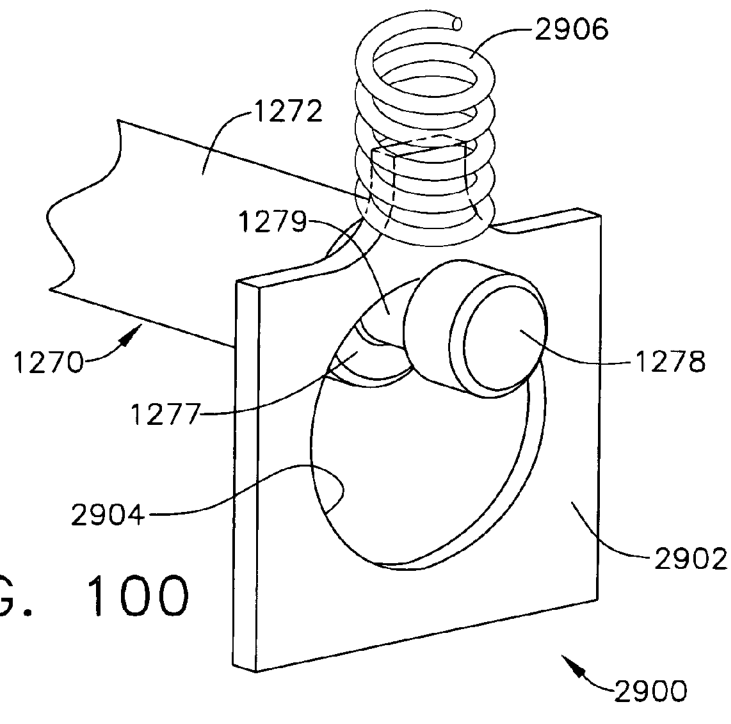



FIG. 100

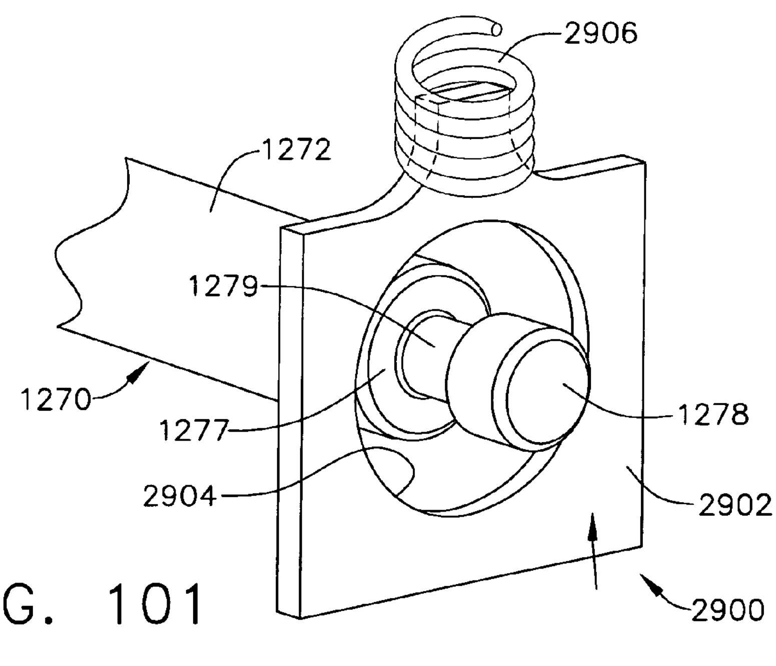
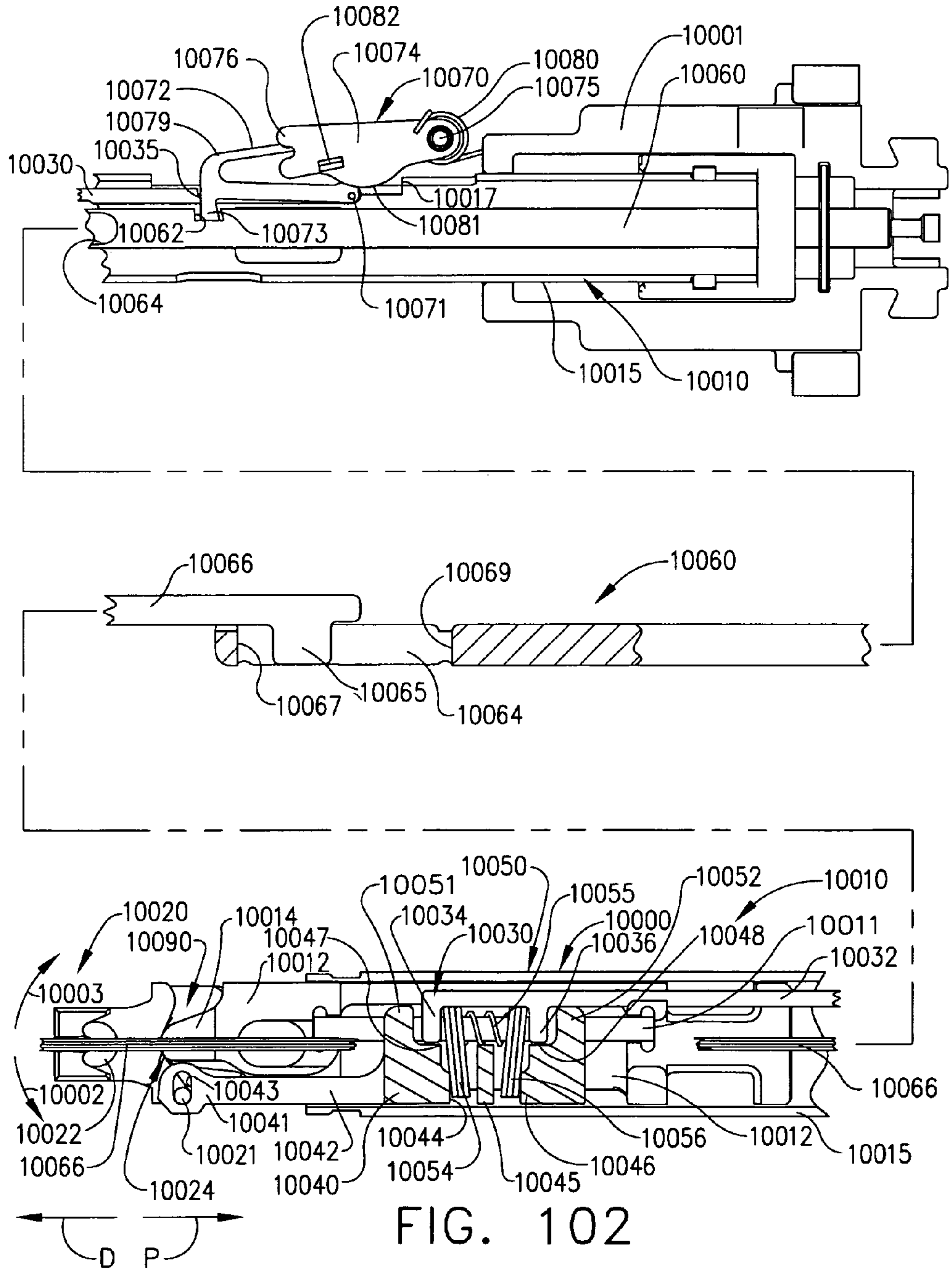



FIG. 101



10082
10076
10074
10070
10080
10001
10072
10075
10060
10079
10035
10030
10017
10062
10073
10081
10064
10071
10015
10010
10066
10060
10069
10067
10065
10064
10051
10050
10055
10052
10010
10020
10014
10034
10000
10090
10047
10030
10036
10048
10011
10012
10032
10003
10066
10002
10043
10022
10041
10021
10042
10044
10056
10012
10015
10066
10054
10045
10046
10024
10040
D
P


FIG. 102

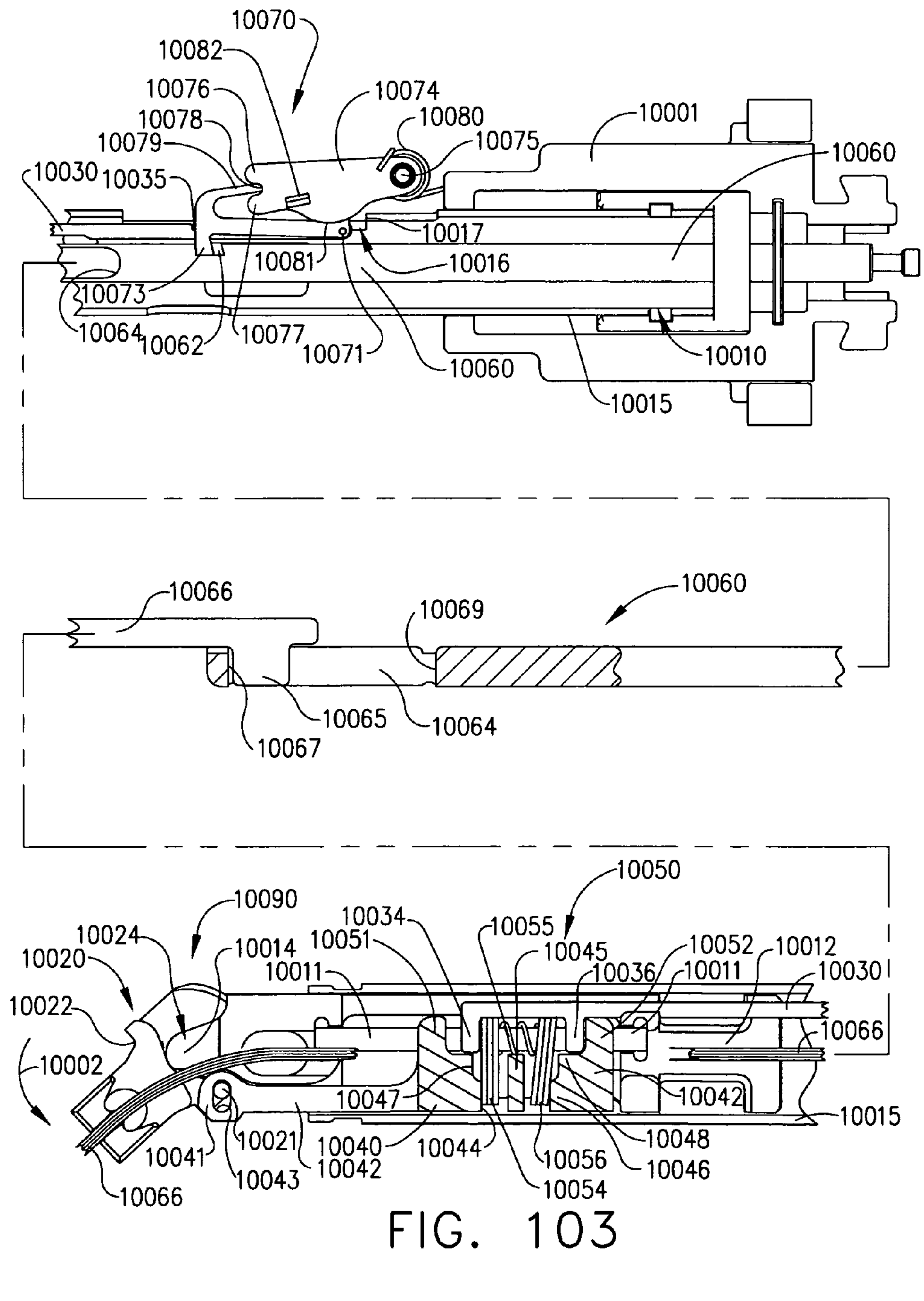

10070
10082
10076
10074
10078
10080
10079
10075
10001
10030
10035
10060
10017
10081
10016
10073
10064
10062
10077
10071
10060
10010
10015
10066
10060
10069
10065
10064
10067
10050
10090
10034
10055
10024
10014
10051
10045
10052
10012
10020
10011
10036
10011
10030
10022
10066
10002
10047
10042
10015
10041
10021
10040
10044
10048
10042
10056
10046
10066
10043
10054

FIG. 103

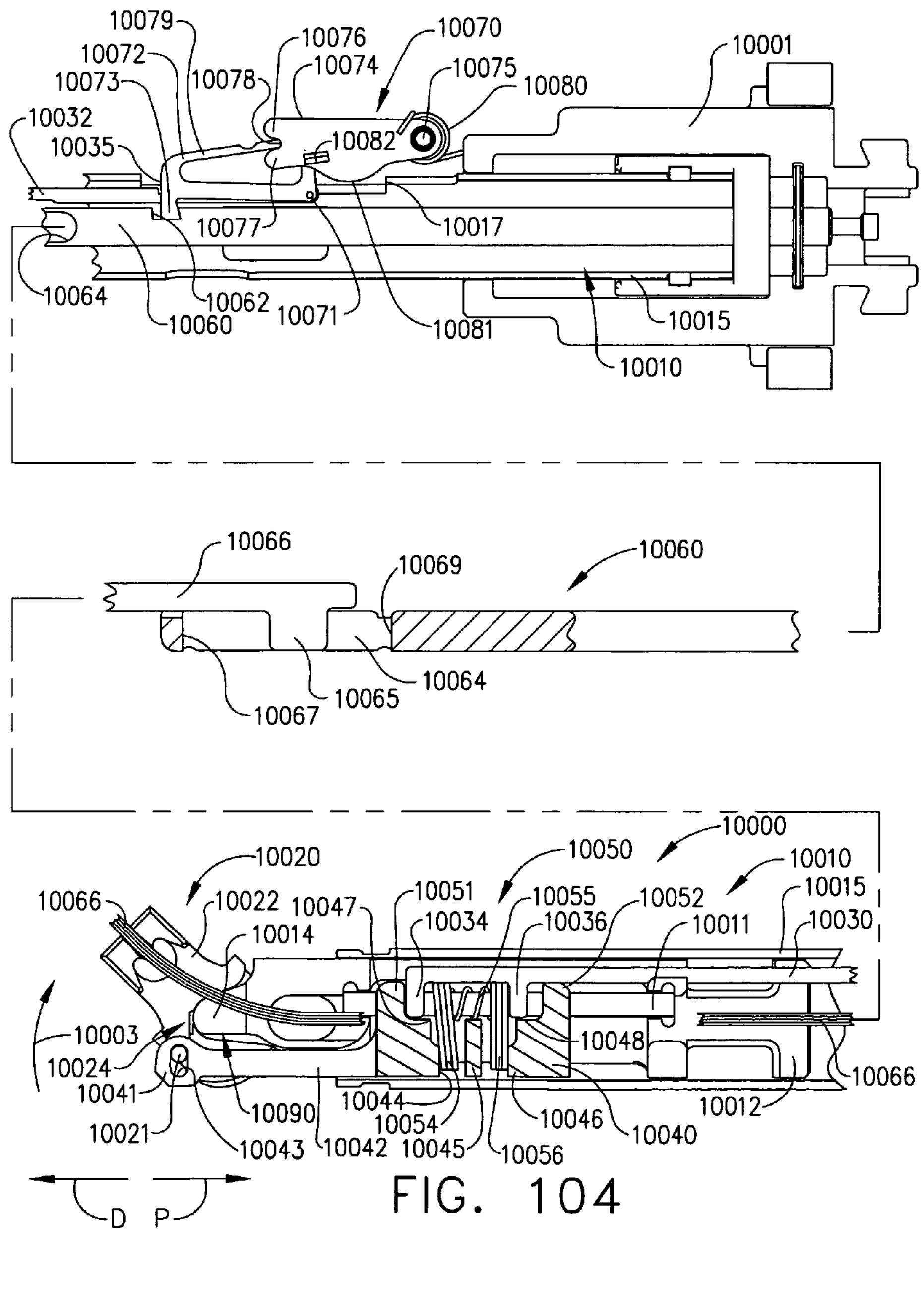

10079
10072
10073
10032
10035
10078
10076
10074
10070
10075
10080
10082
10001
10077
10017
10064
10062
10060
10071
10081
10015
10010
10066
10069
10060
10067
10065
10064
10000
10020
10050
10010
10066
10022
10047
10051
10055
10052
10015
10034
10036
10011
10030
10014
10003
10048
10024
10041
10090
10044
10054
10046
10040
10012
10066
10021
10043
10042
10045
10056
D
P

FIG. 104

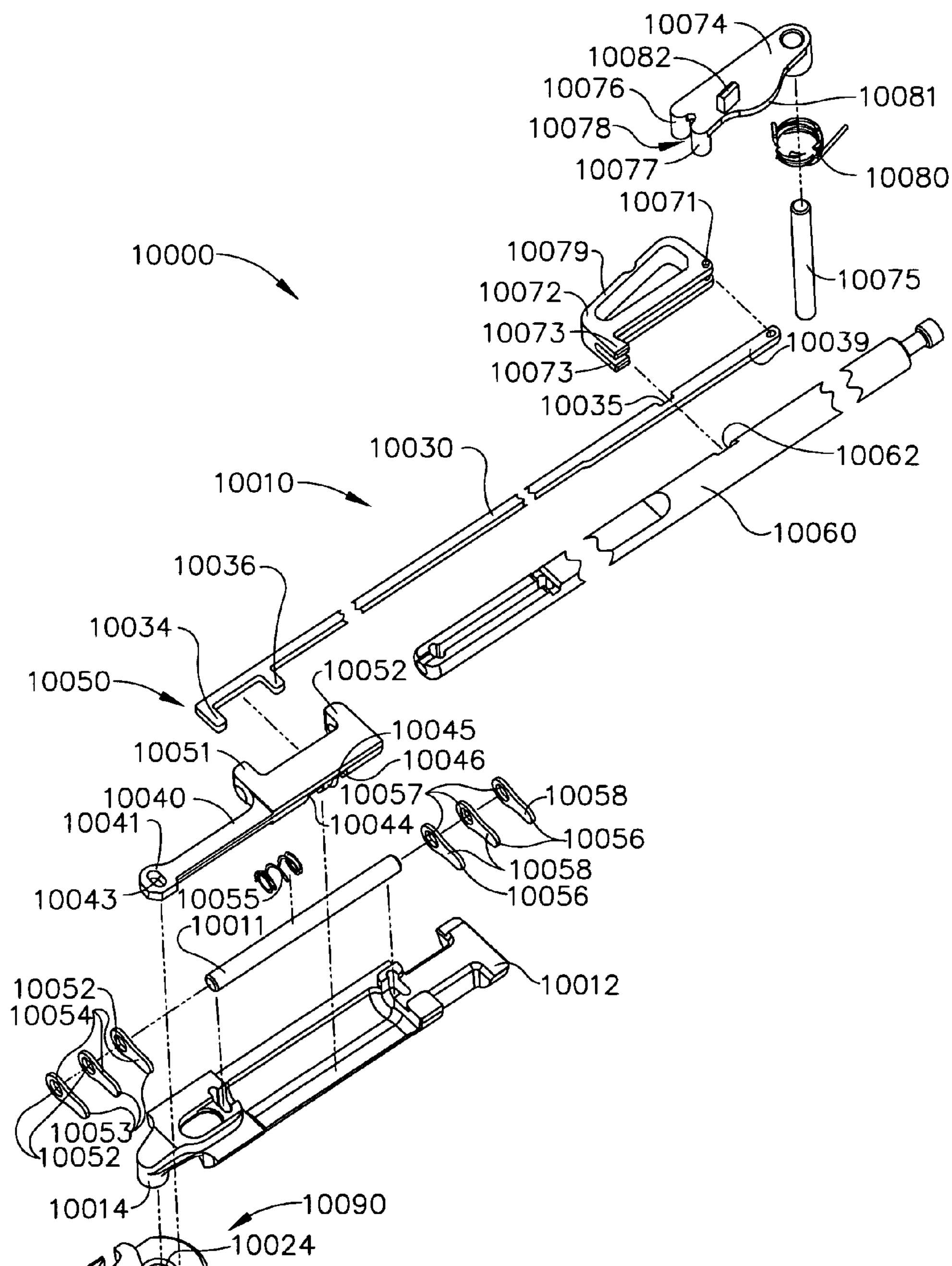

10074
10082
10076
10081
10078
10080
10077
10071
10075
10000
10079
10072
10073
10039
10073
10035
10062
10030
10010
10060
10036
10034
10052
10050
10045
10051
10046
10057
10058
10040
10044
10056
10041
10058
10043
10055
10056
10011
10012
10052
10054
10053
10052
10014
10090
10024
10021
10022

FIG. 104A

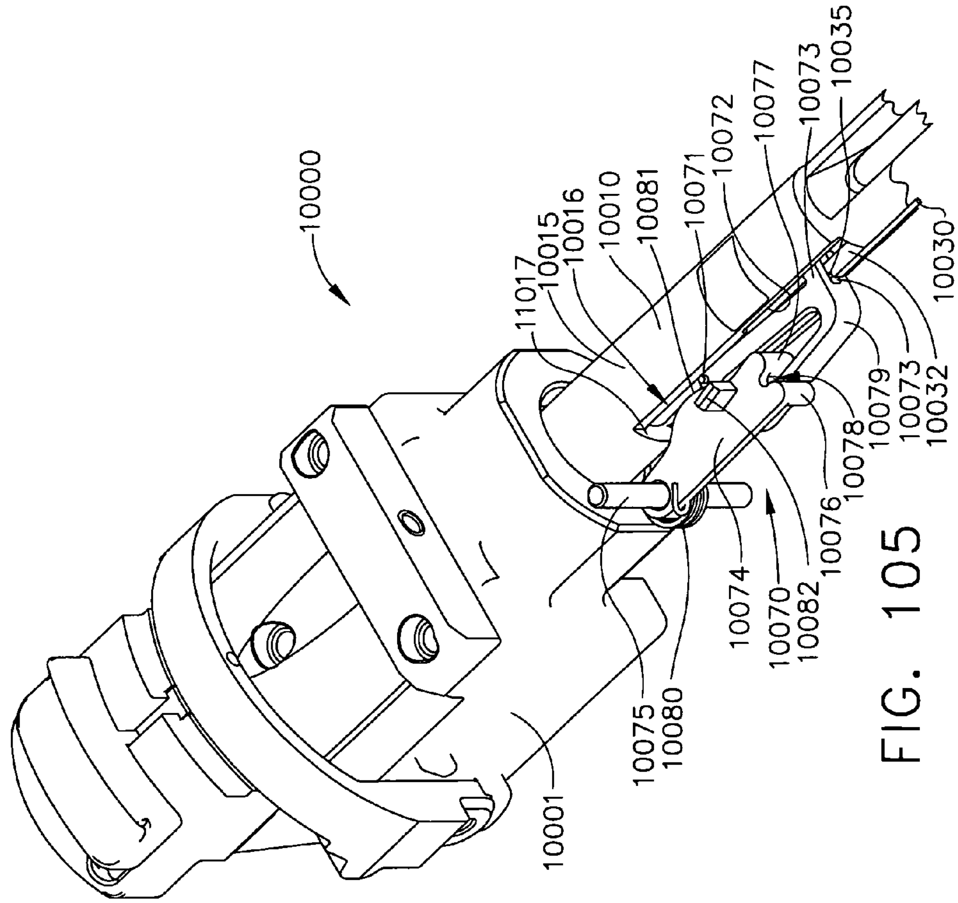

10000
11017
10015
10016
10010
10081
10071
10072
10077
10073
10035
10030
10079
10073
10032
10078
10076
10082
10070
10074
10075
10080
10001

FIG. 105

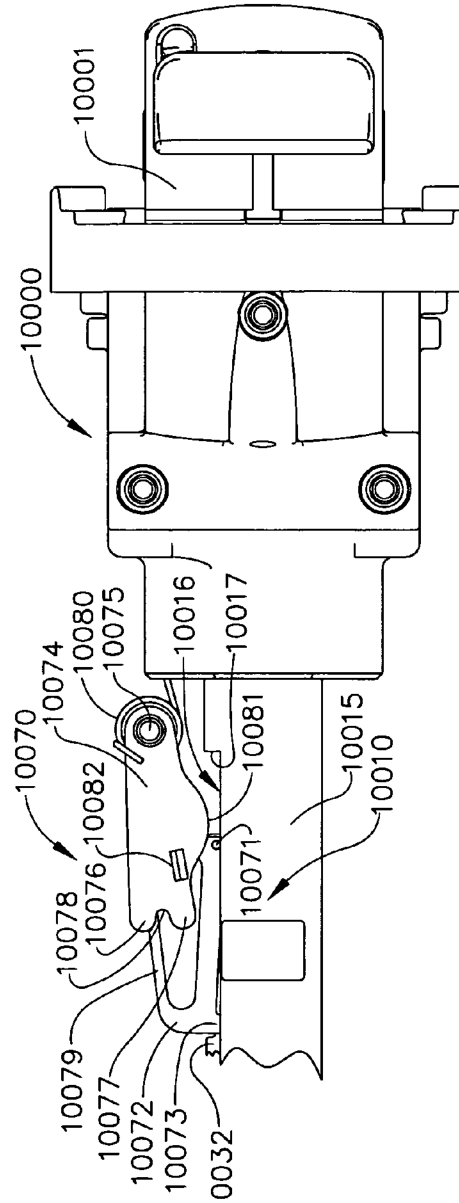



FIG. 106

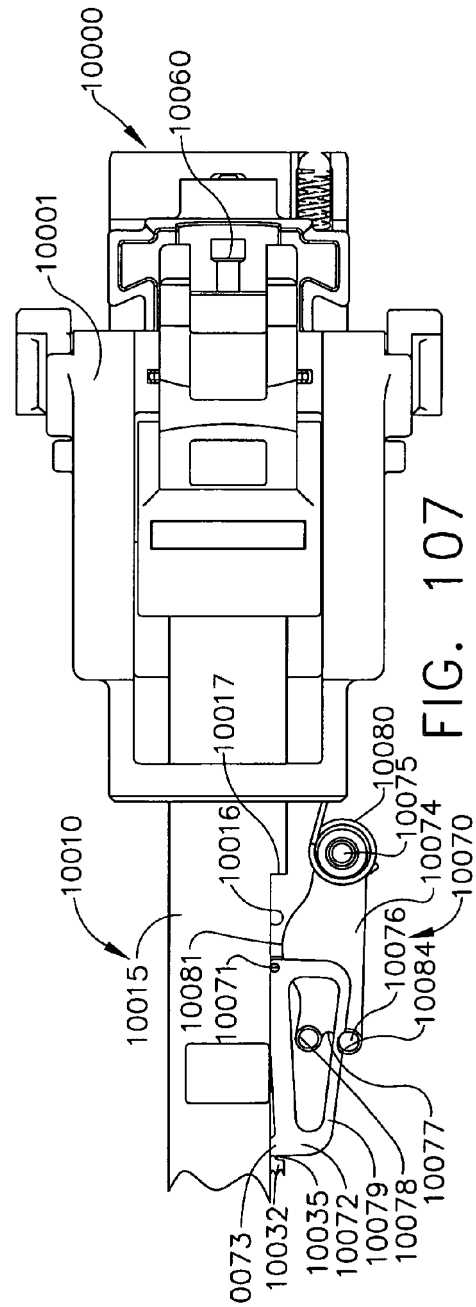
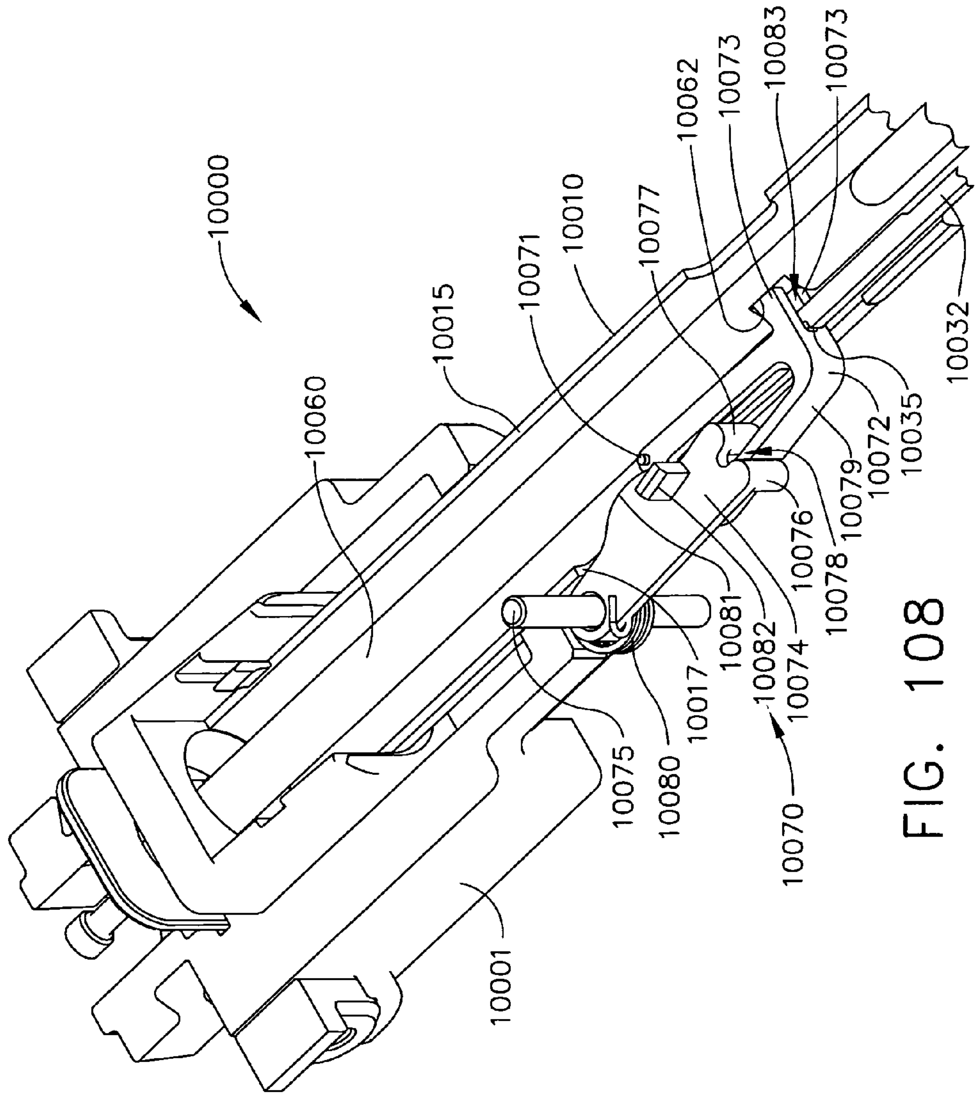



FIG. 107


10000
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10071
10010
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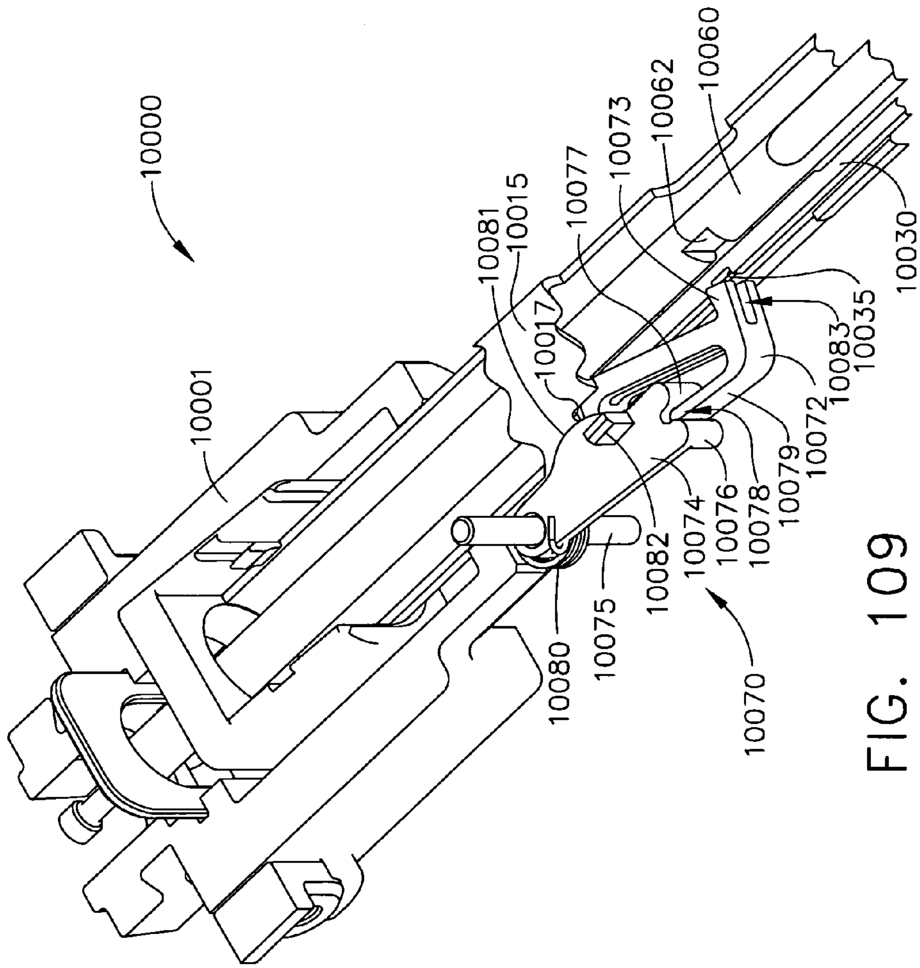
10062
10073
10083
10073
10032
10035
10072
10079
10078
10076
10081
10082
10074
10017
10080
10075
10070
10001

FIG. 108



10000
10001
10081
10015
10017
10077
10073
10062
10060
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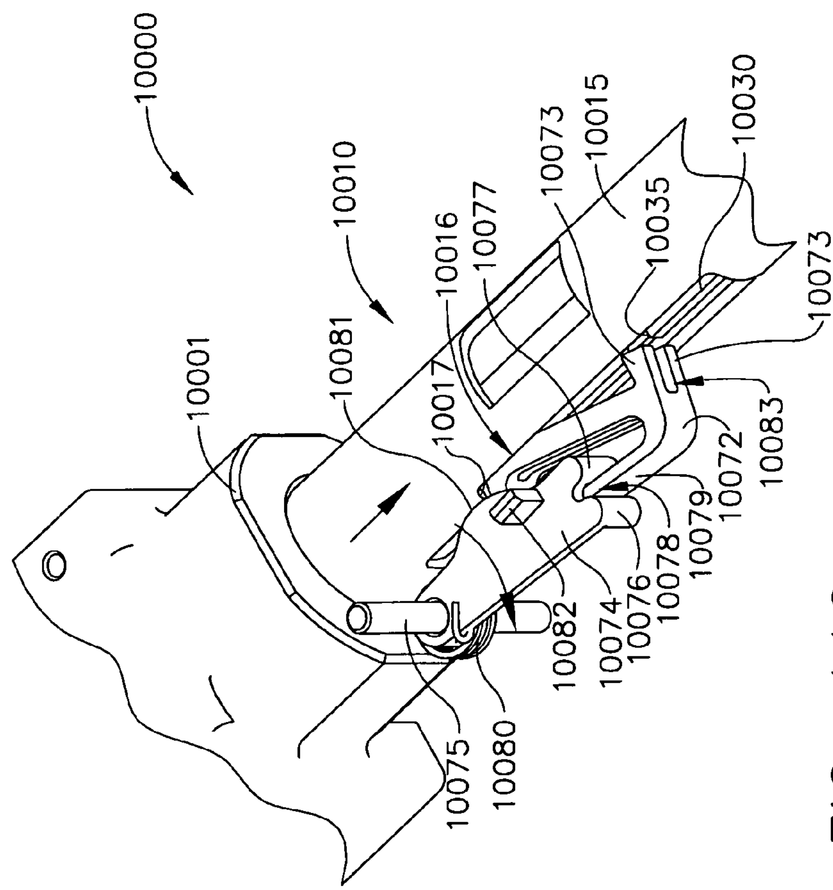
10035
10083
10072
10079
10078
10076
10074
10082
10075
10080
10070


FIG. 109



10000
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10001
10081
10017
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10077
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10030
10073
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10072
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10078
10076
10074
10082
10075
10080


FIG. 110

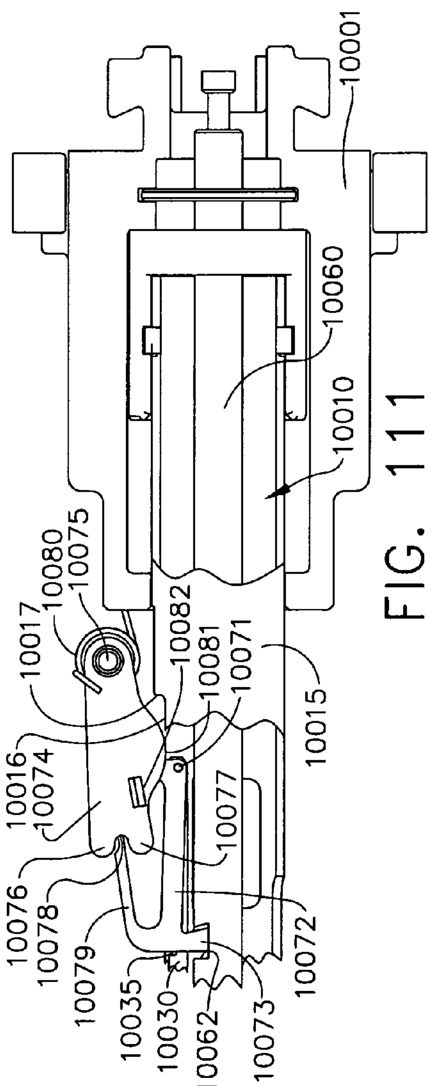


FIG. 111

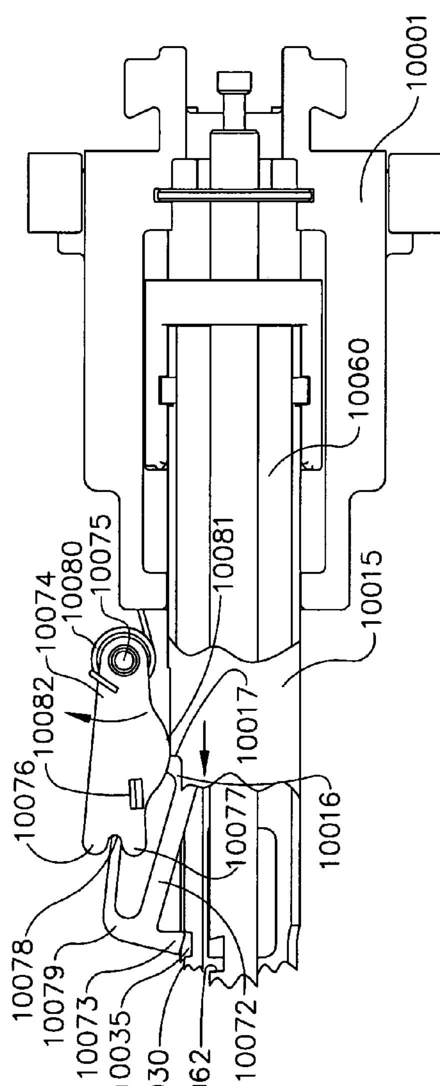


FIG. 112

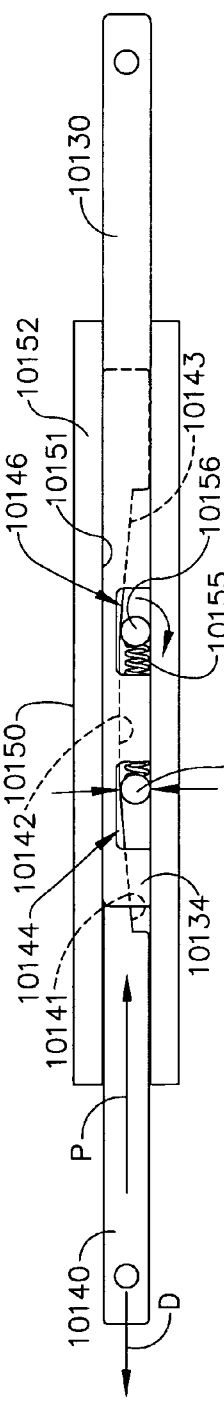



FIG. 113

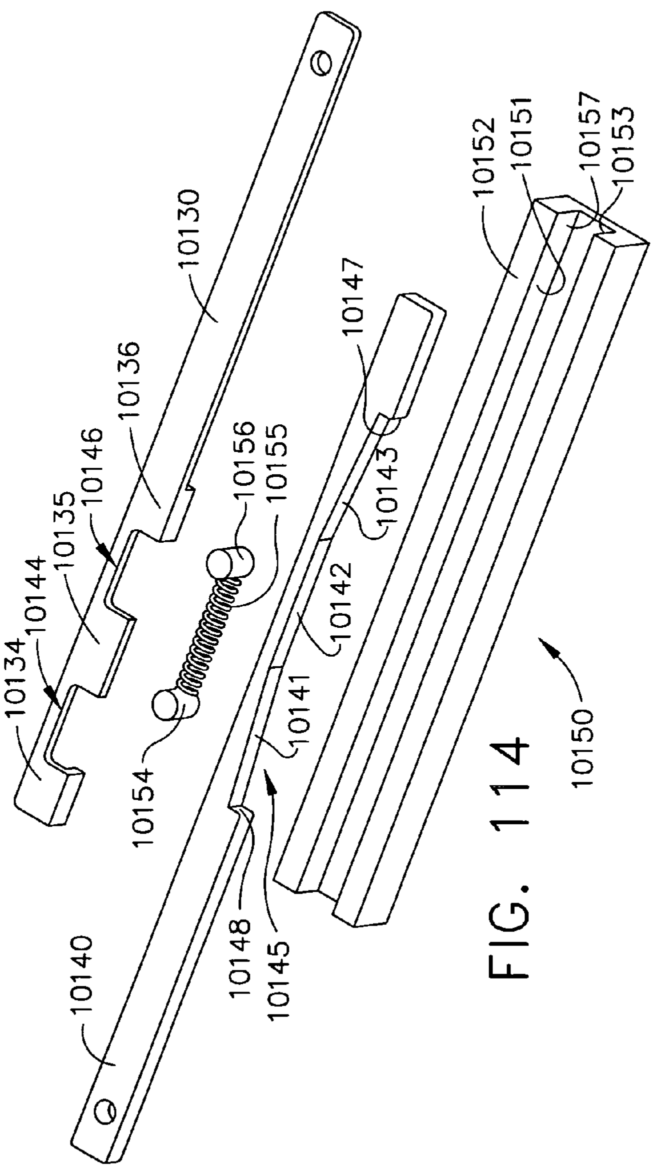



FIG. 114

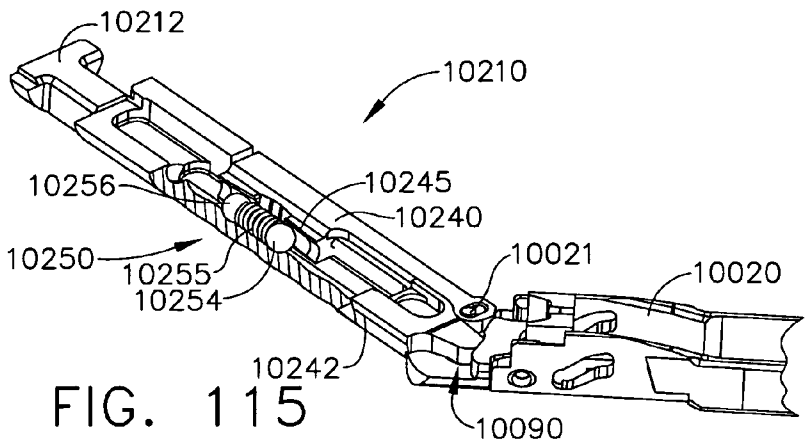



FIG. 115

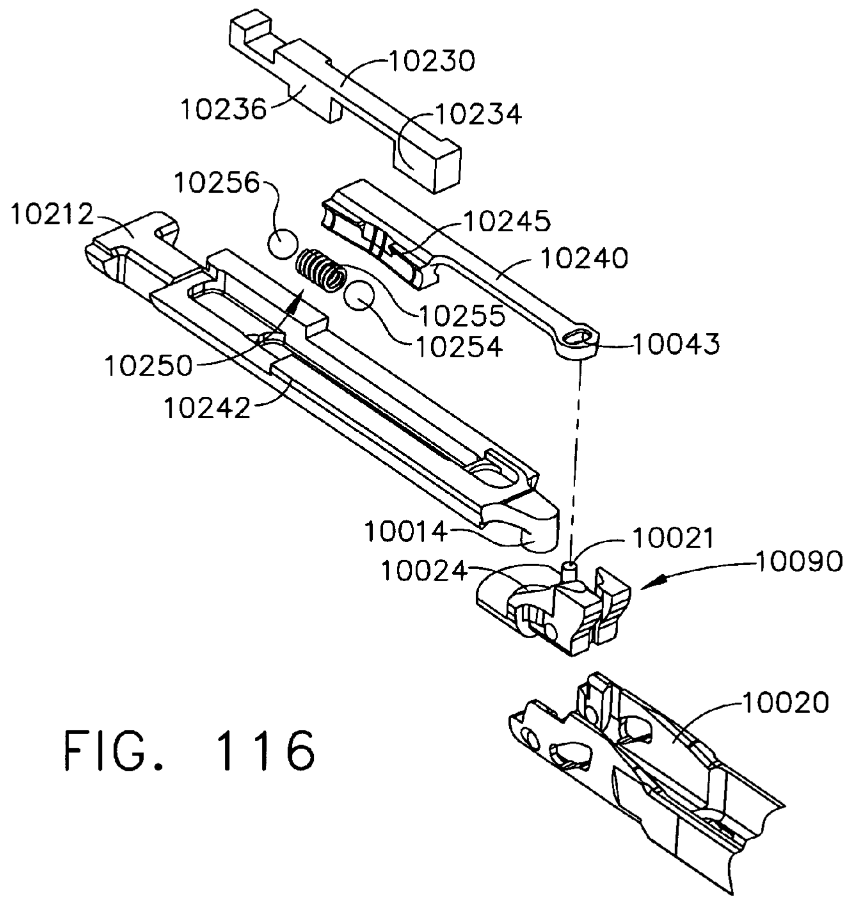



FIG. 116

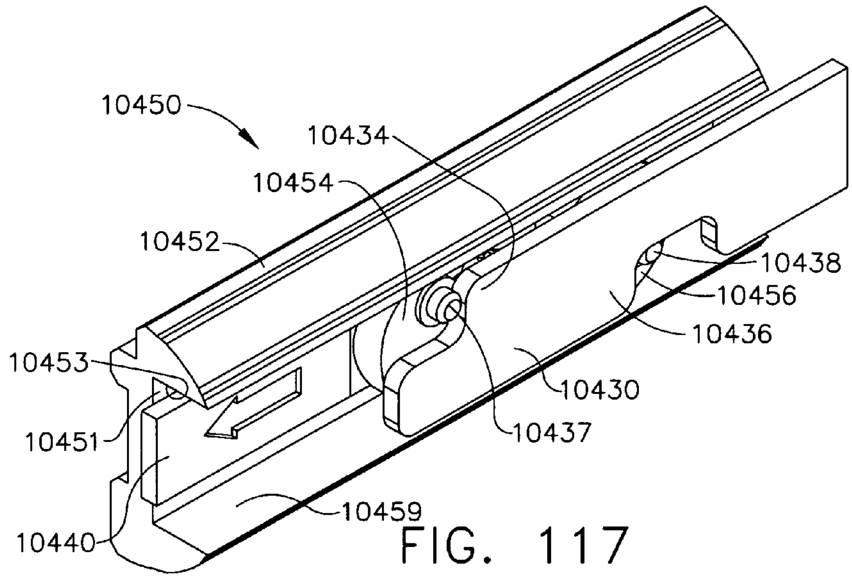



FIG. 117

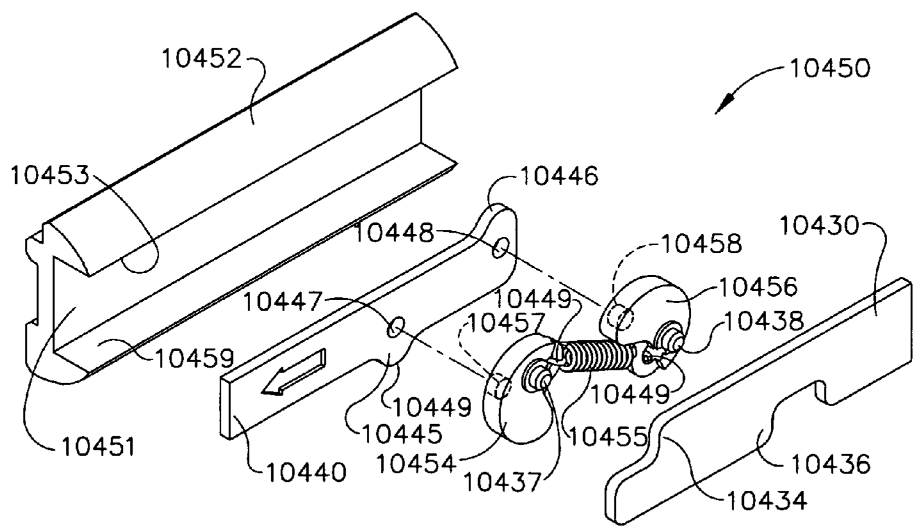



FIG. 118

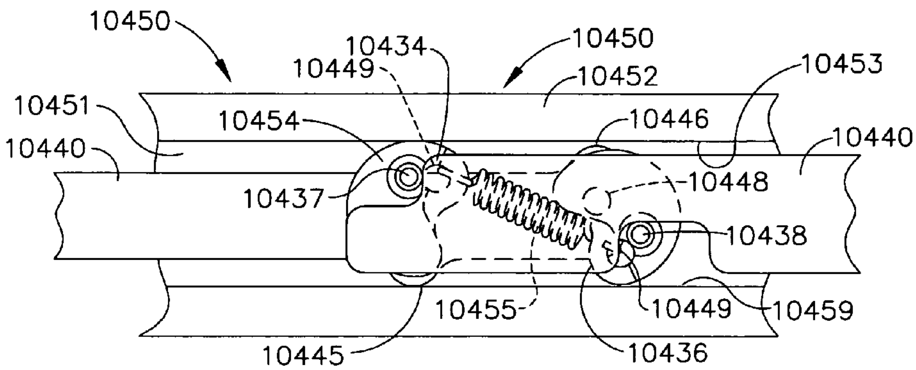



FIG. 119

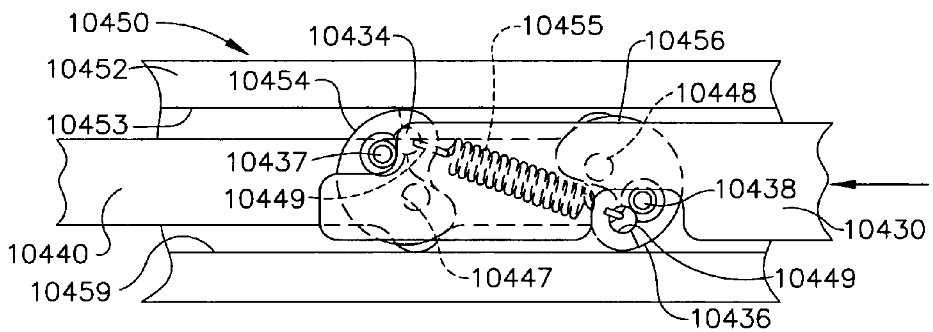



FIG. 120

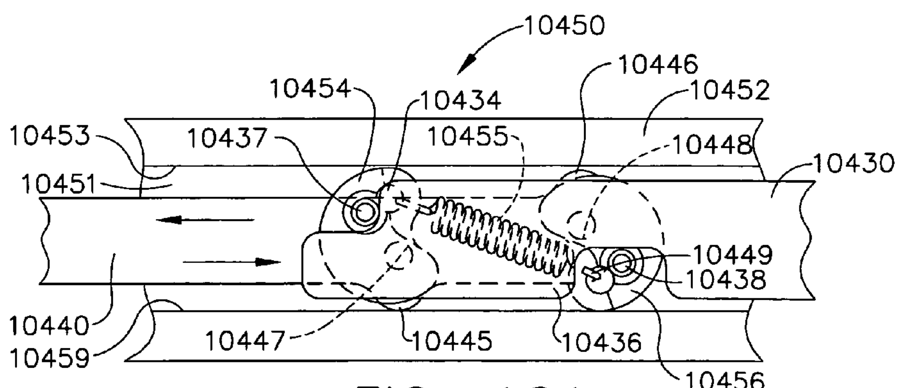
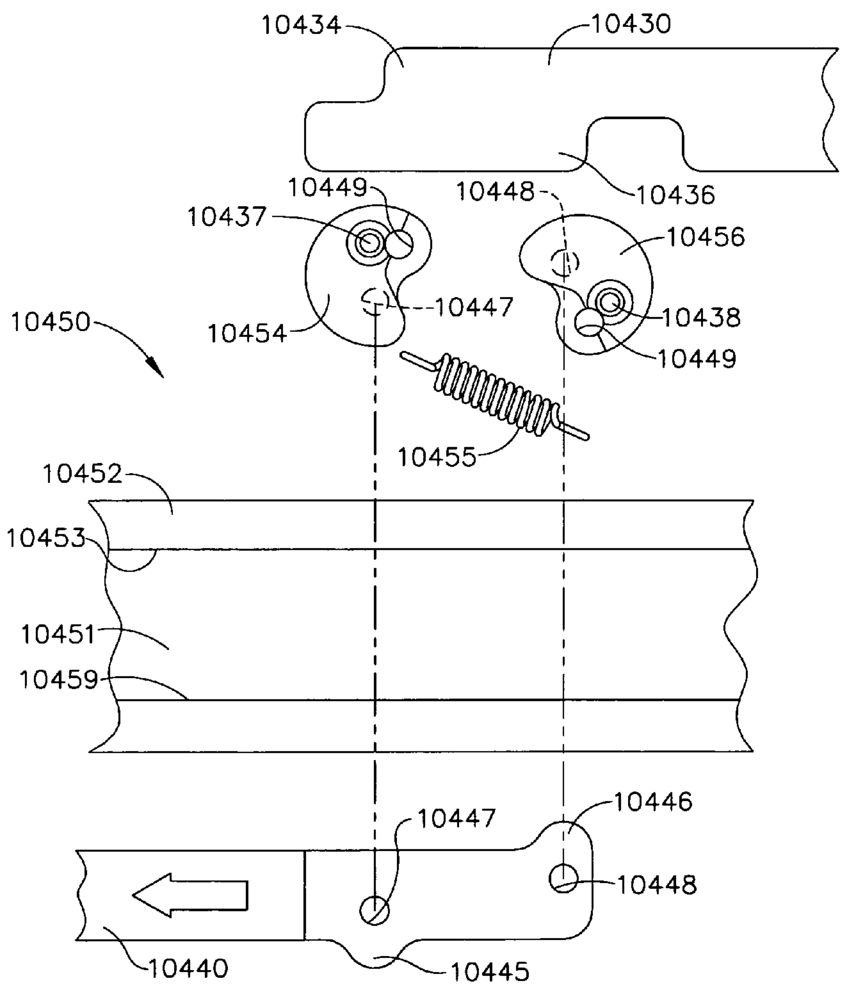



FIG. 121


10434
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10436
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10449
10455
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10453
10451
10459
10446
10447
10448
10440
10445

FIG. 122

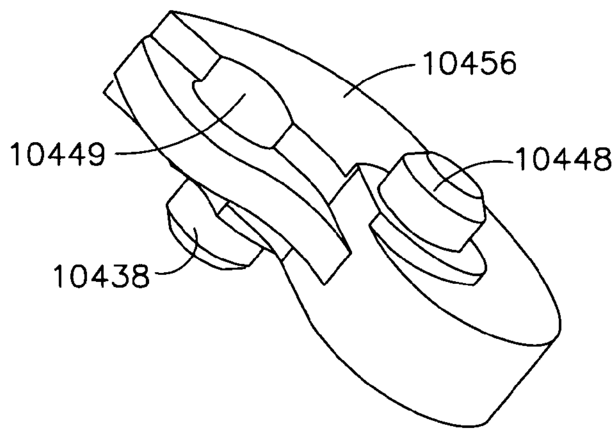



FIG. 123

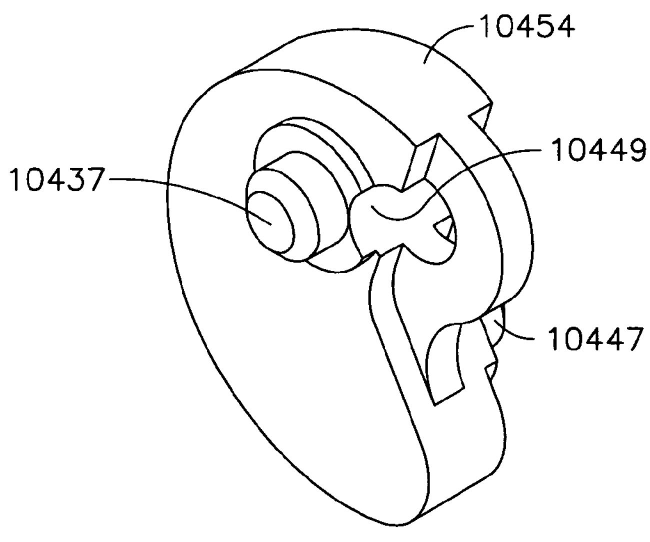



FIG. 124

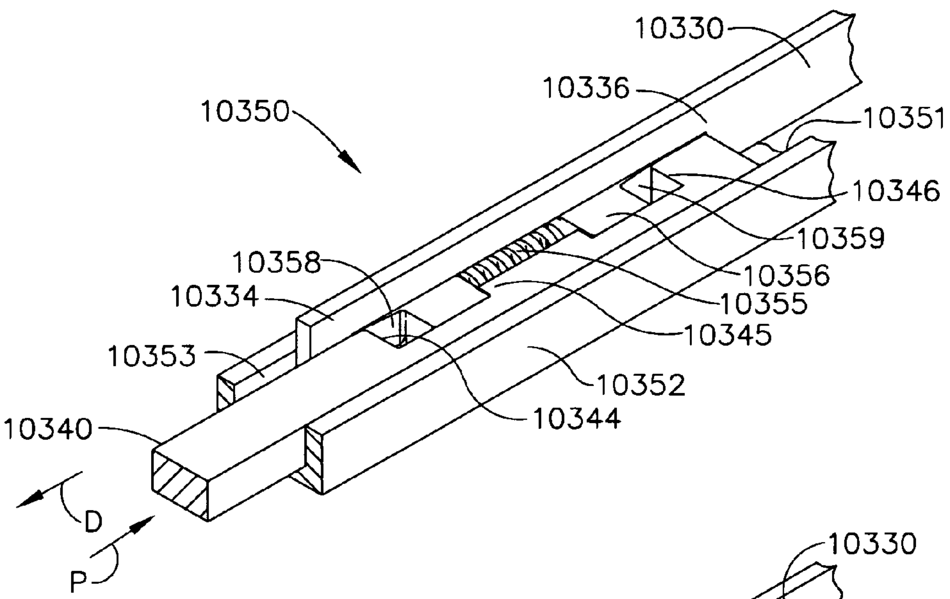



FIG. 125

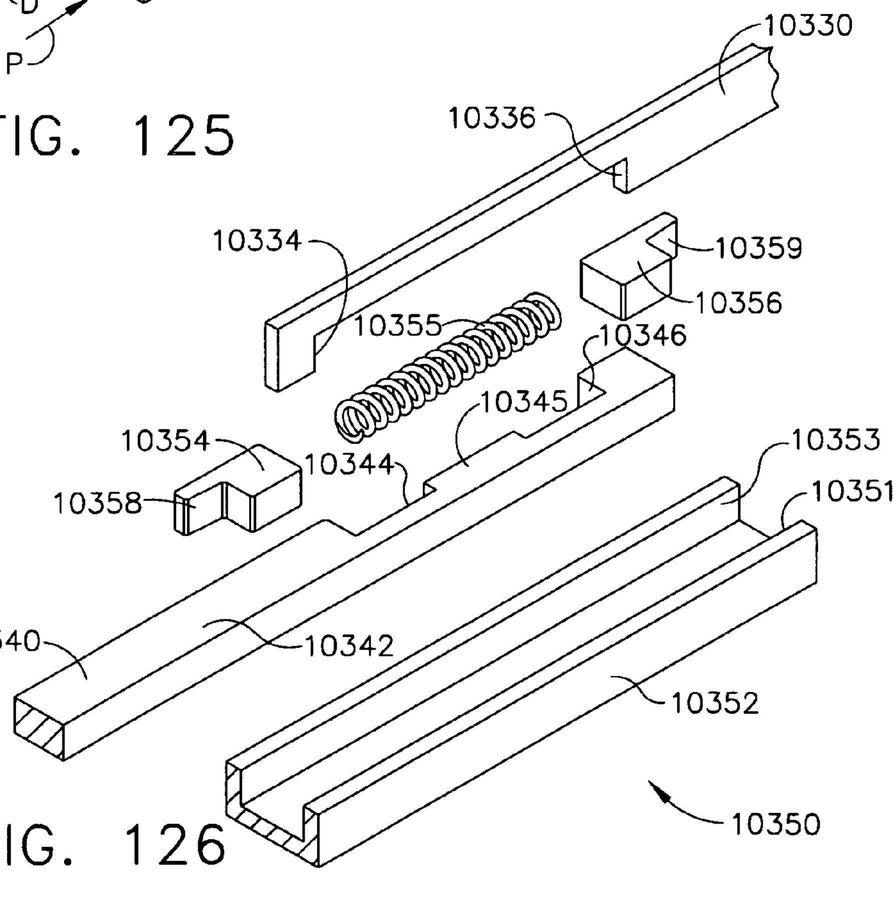



FIG. 126

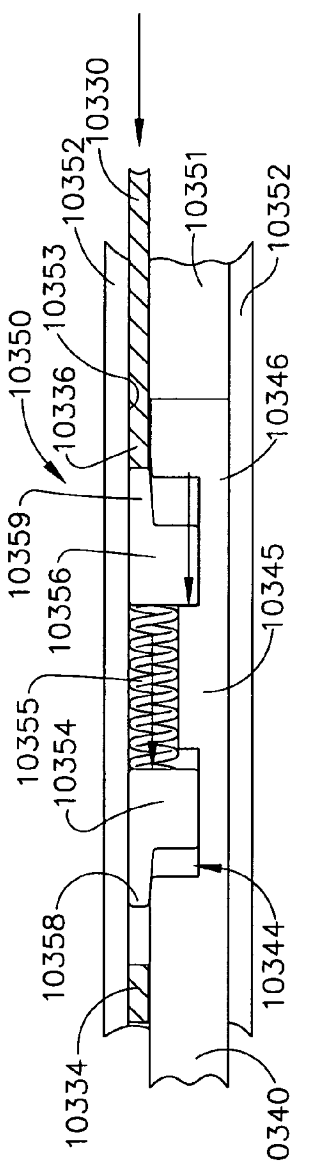



FIG. 127

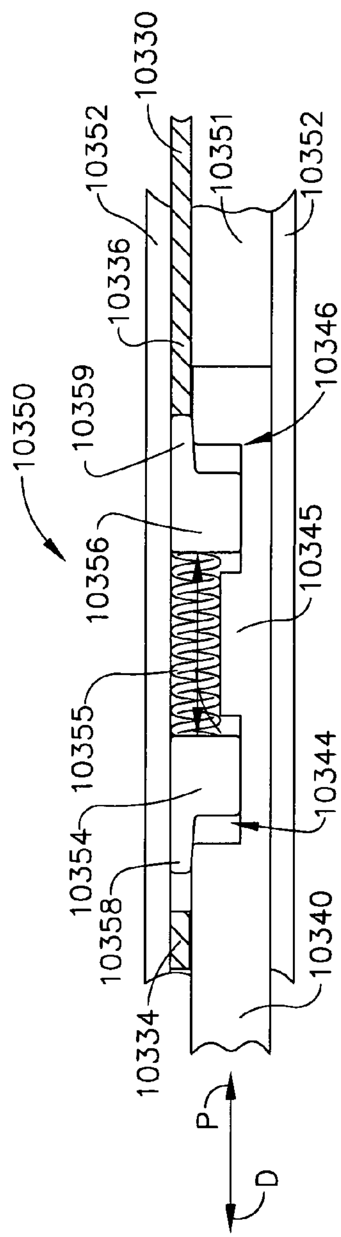



FIG. 128

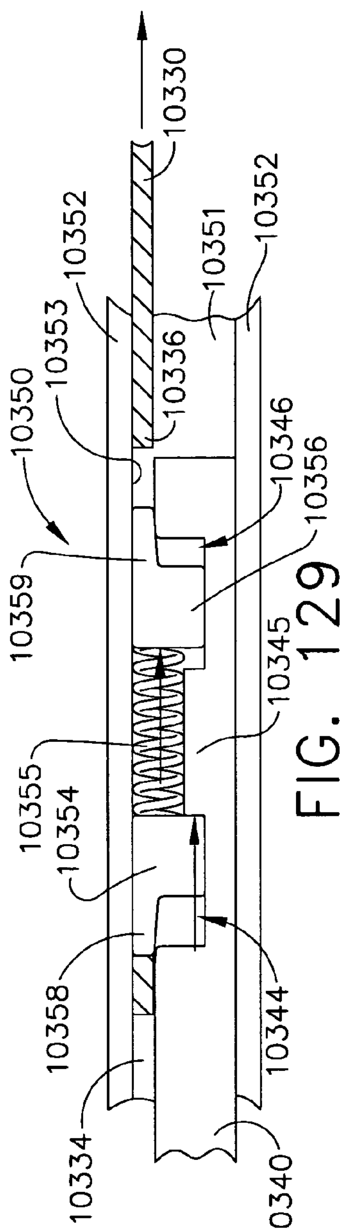



FIG. 129

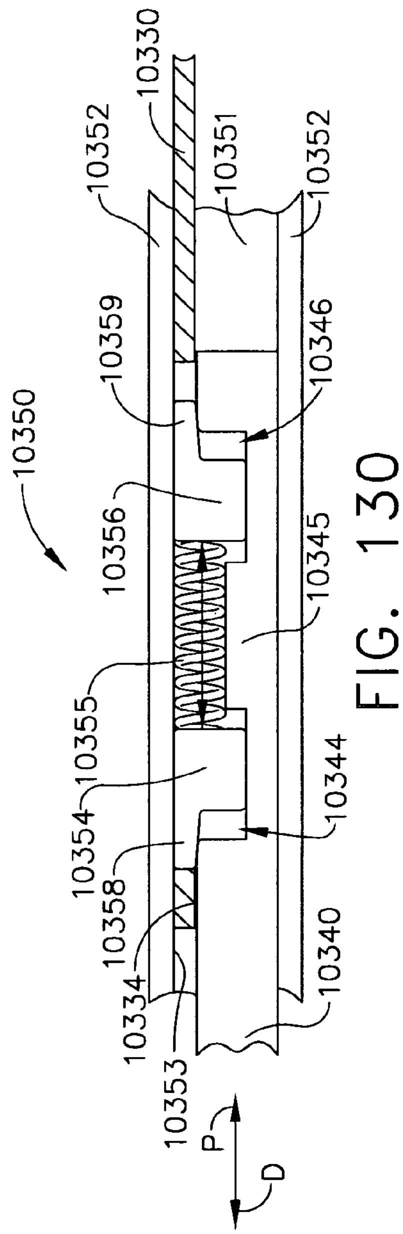



FIG. 130

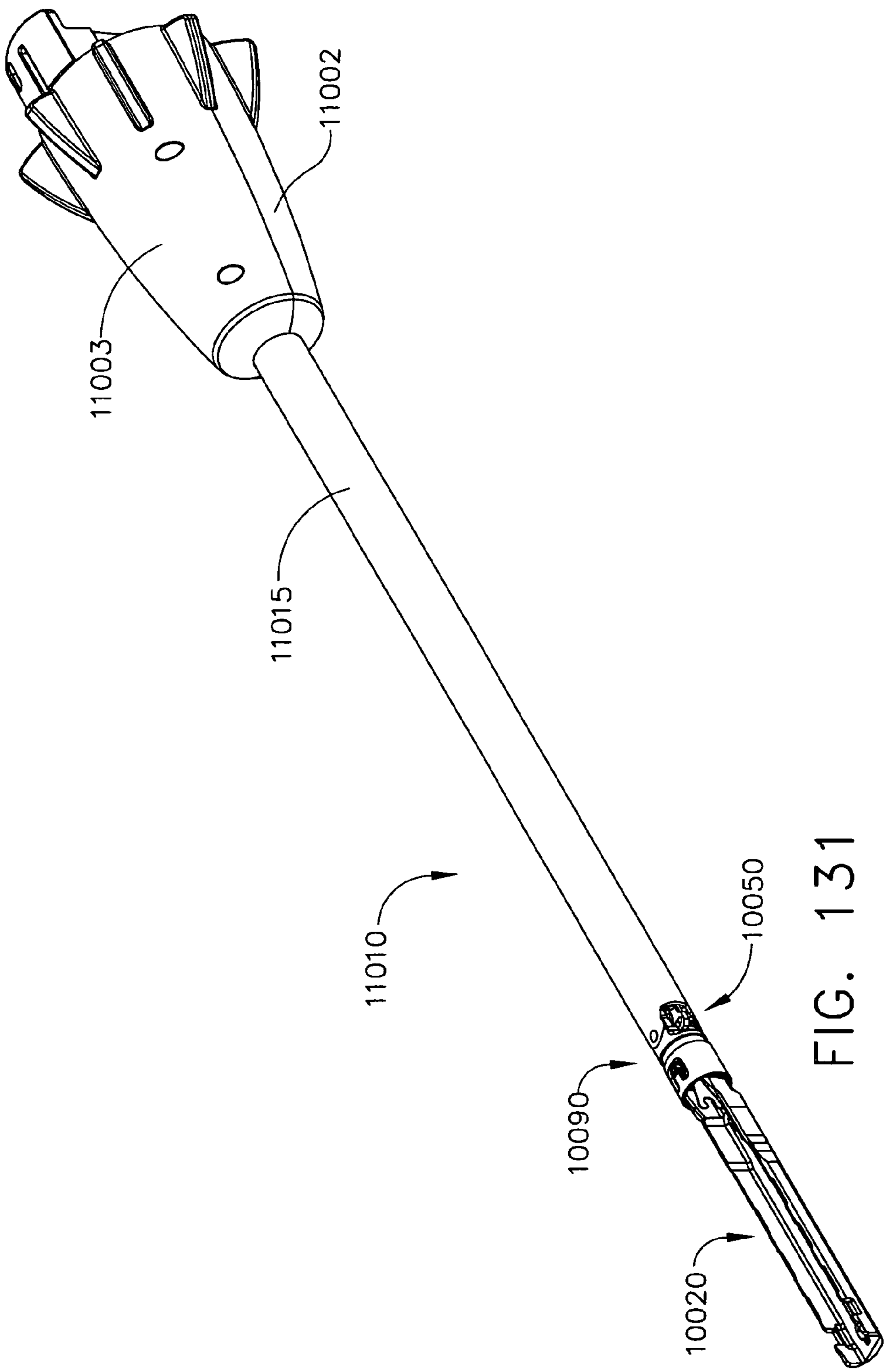



FIG. 131

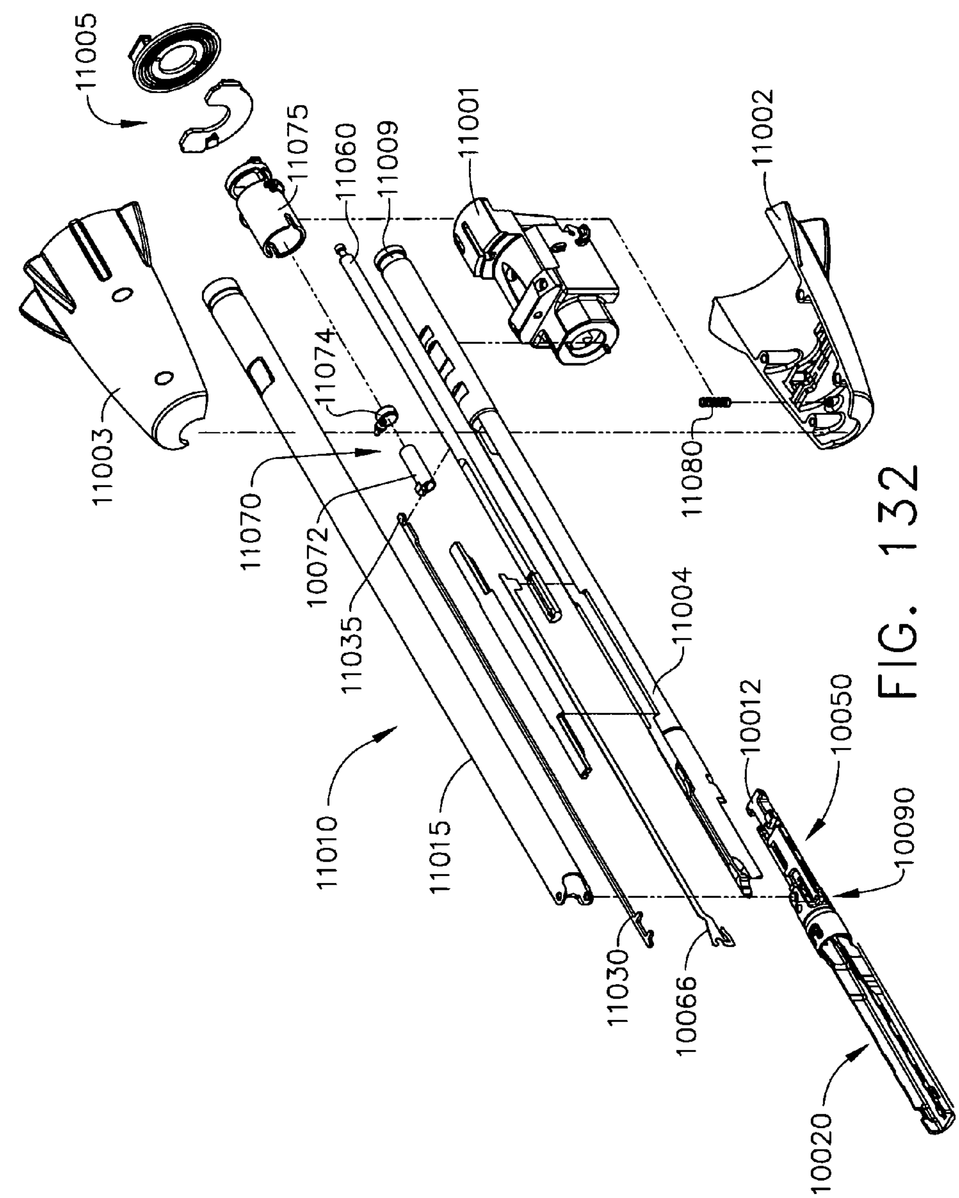

11005
11075
11060
11009
11001
11002
11003
11074
11070
10072
11035
11080
11004
11010
11015
10012
10050
10090
11030
10066
10020

FIG. 132

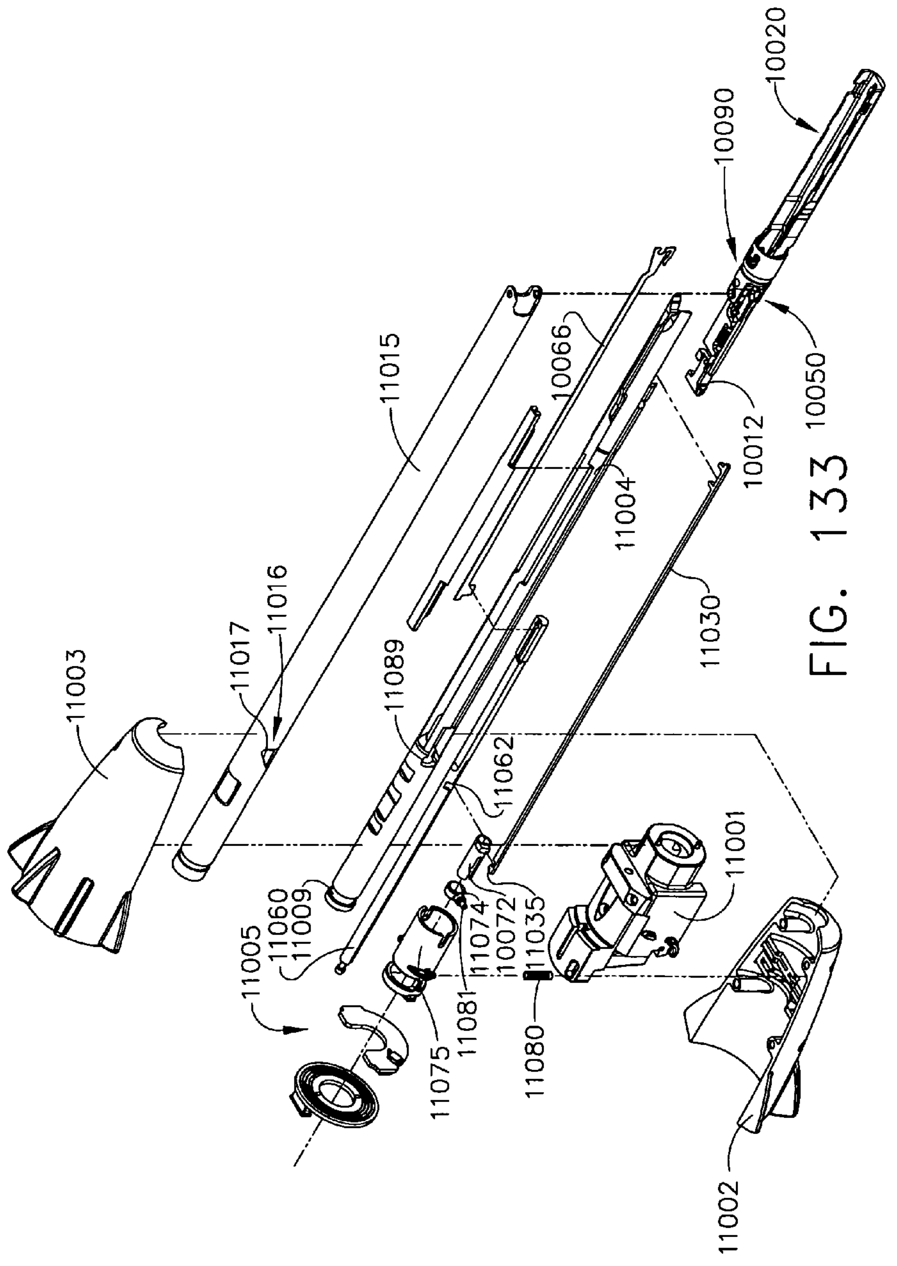
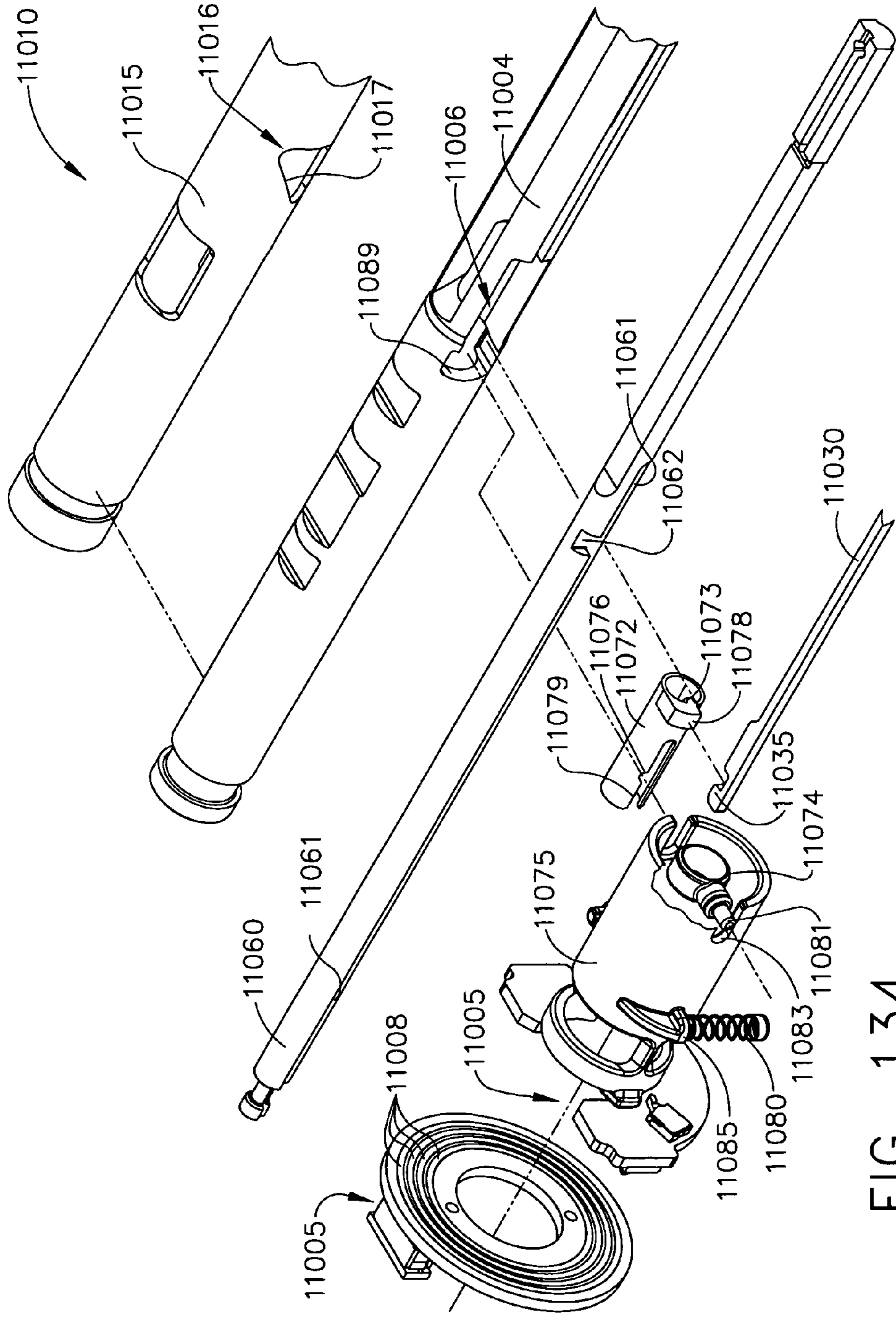

10020
10090
10050
10012
11015
10066
11004
11030
11003
11017
11016
11089
11062
11001
11005
11060
11009
11074
10072
11035
11081
11075
11080
11002

FIG. 133


11010
11015
11016
11017
11004
11006
11089
11061
11062
11030
11073
11078
11076
11072
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11035
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11075
11081
11083
11061
11060
11005
11008
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11080
11083
11005

FIG. 134

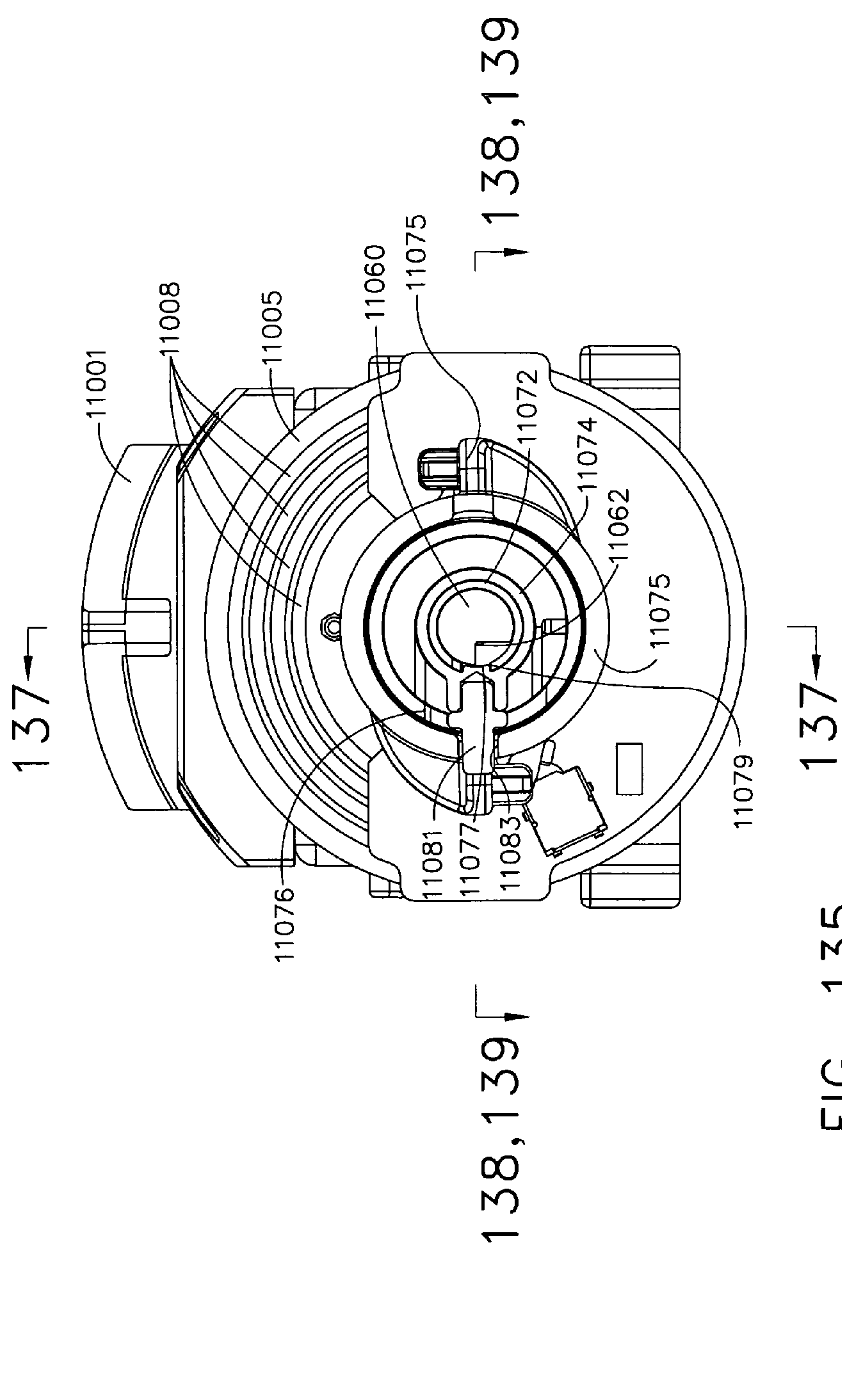

138,139
138,139
137
137
11001
11008
11005
11060
11075
11072
11074
11062
11075
11079
11076
11081
11077
11083

FIG. 135

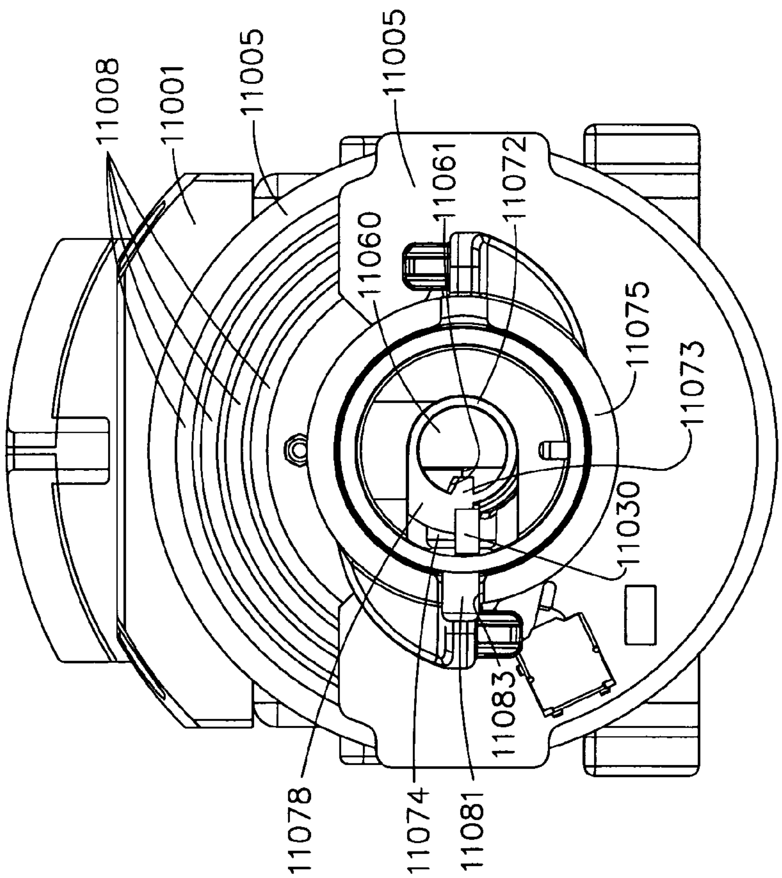

11008
11001
11005
11005
11061
11072
11060
11075
11073
11030
11083
11078
11074
11081

FIG. 136

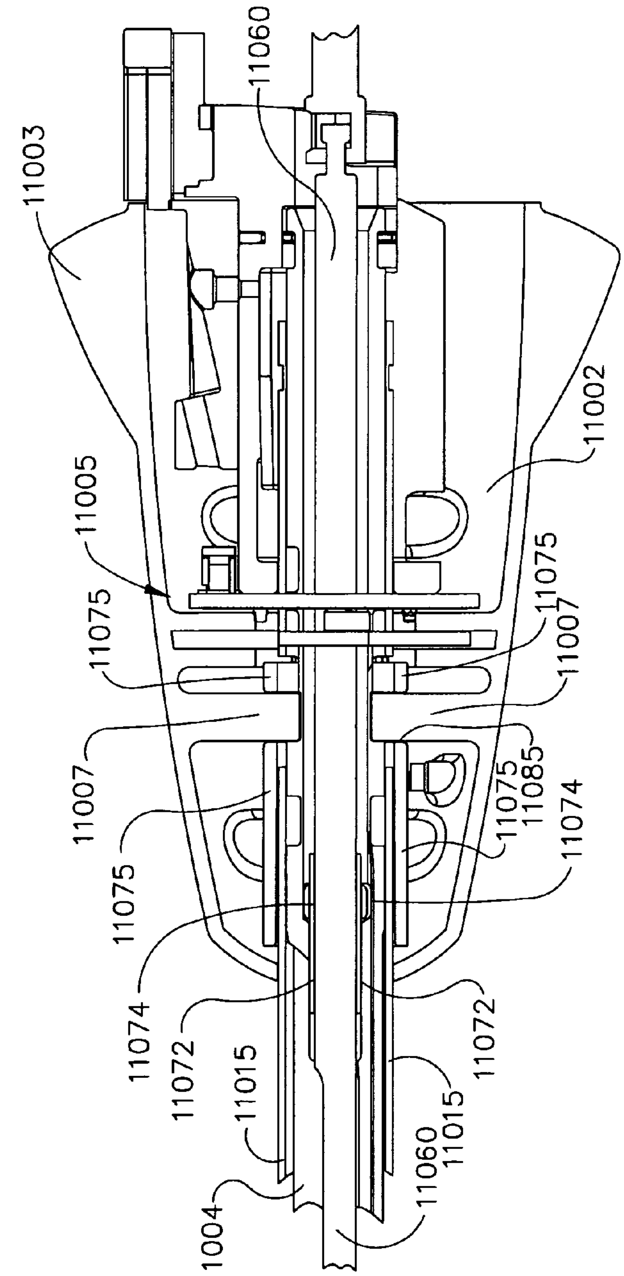

11003
11060
11002
11005
11075
11075
11007
11007
11007
11075
11085
11075
11074
11075
11074
11072
11072
11015
11015
11060
11015
11004

FIG. 137

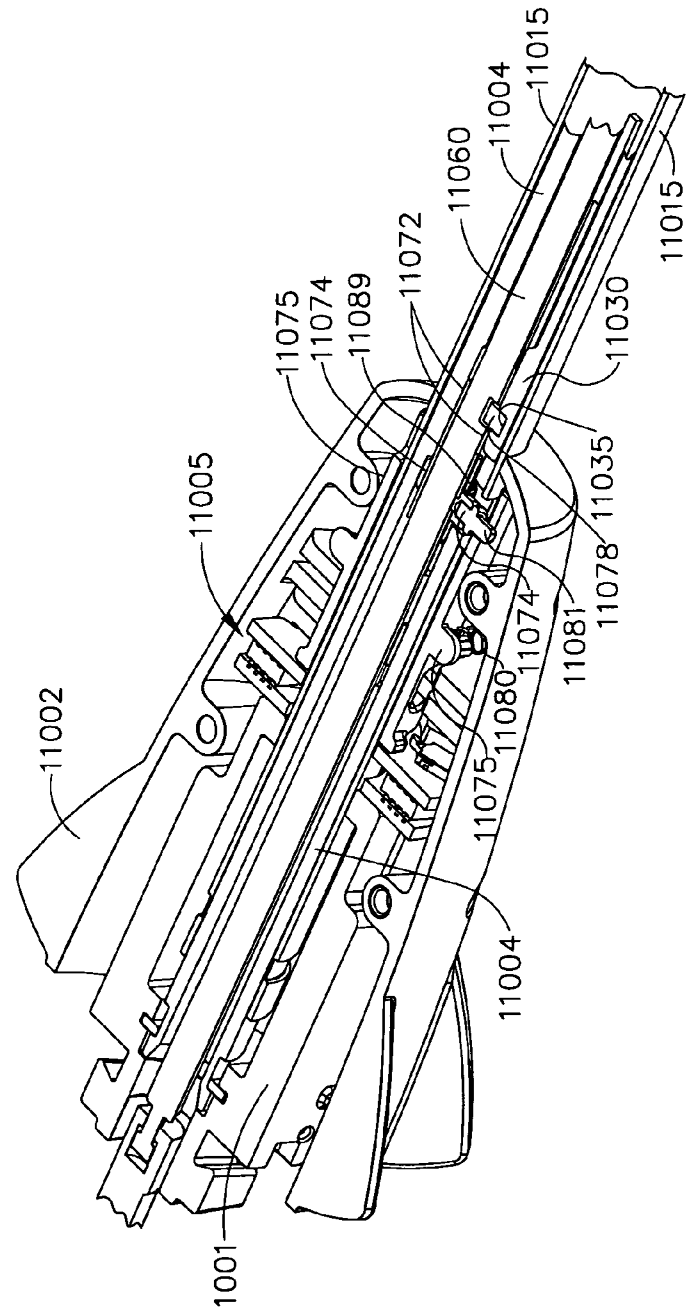
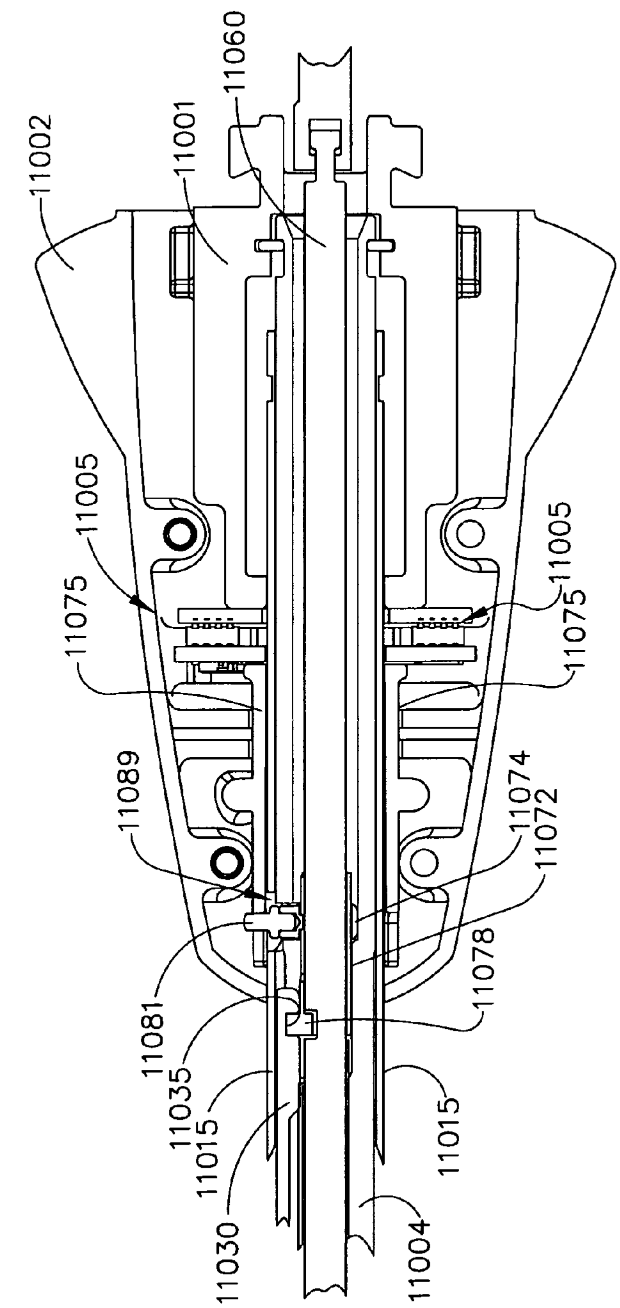

11015
11004
11060
11072
11075
11074
11089
11030
11015
11035
11005
11078
11081
11074
11080
11002
11075
11004
11001

FIG. 138


11060
11002
11001
11005
11075
11005
11075
11089
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11072
11078
11081
11035
11015
11015
11030
11004

FIG. 139

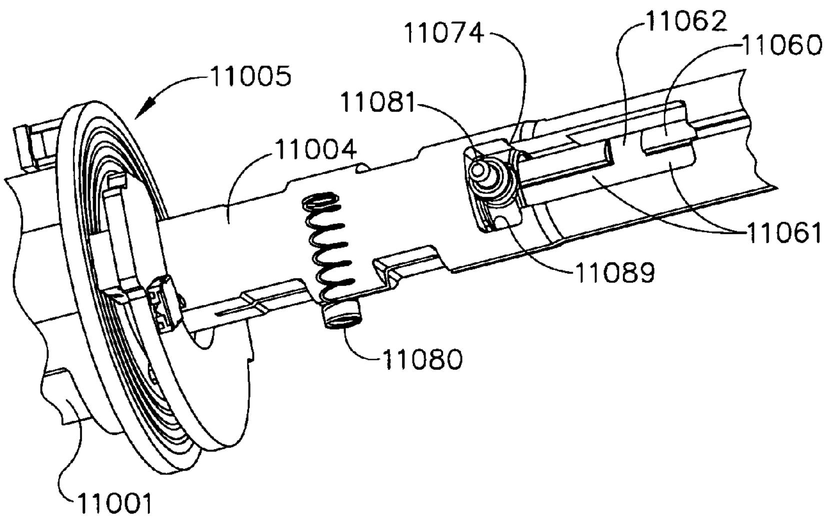



FIG. 140

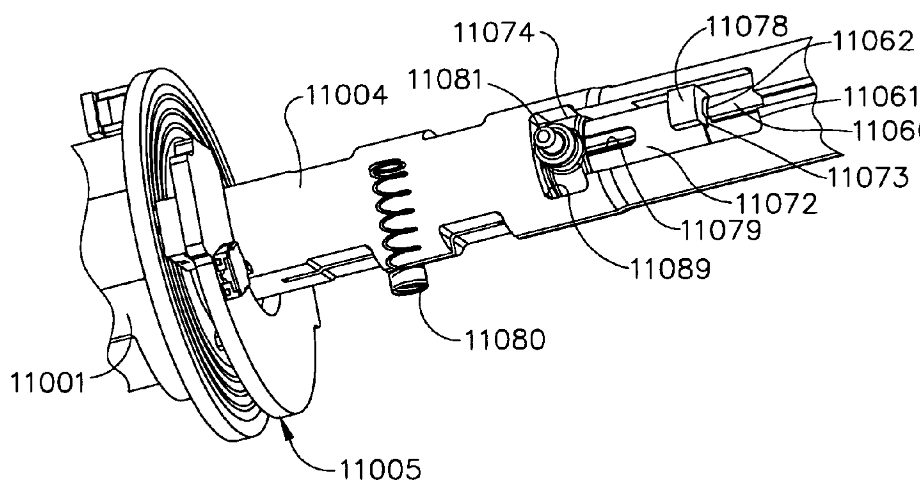



FIG. 141

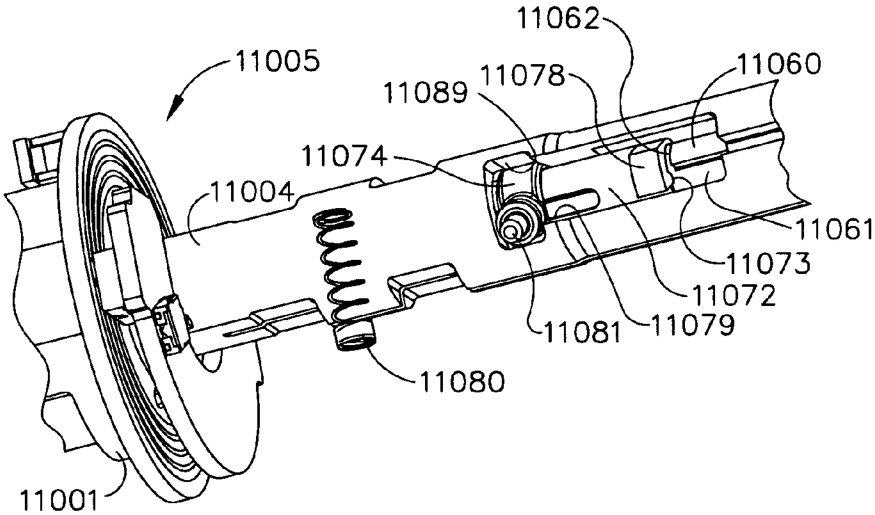



FIG. 142

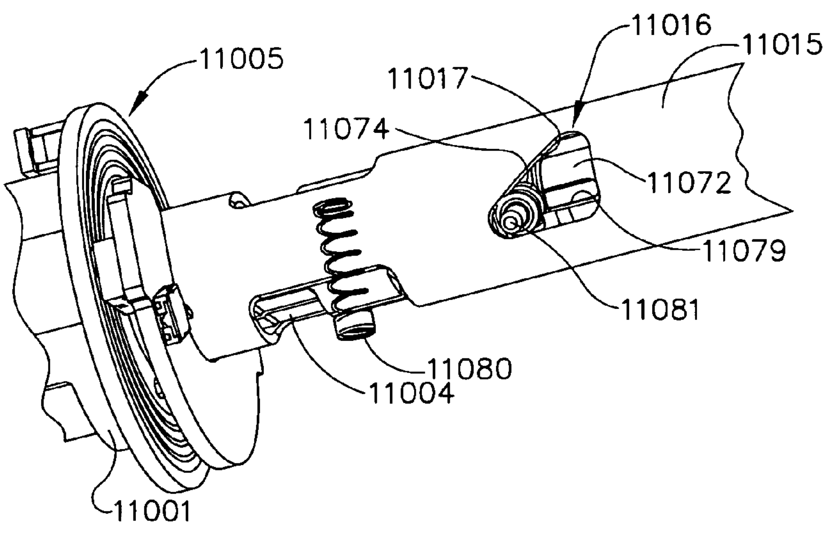



FIG. 143

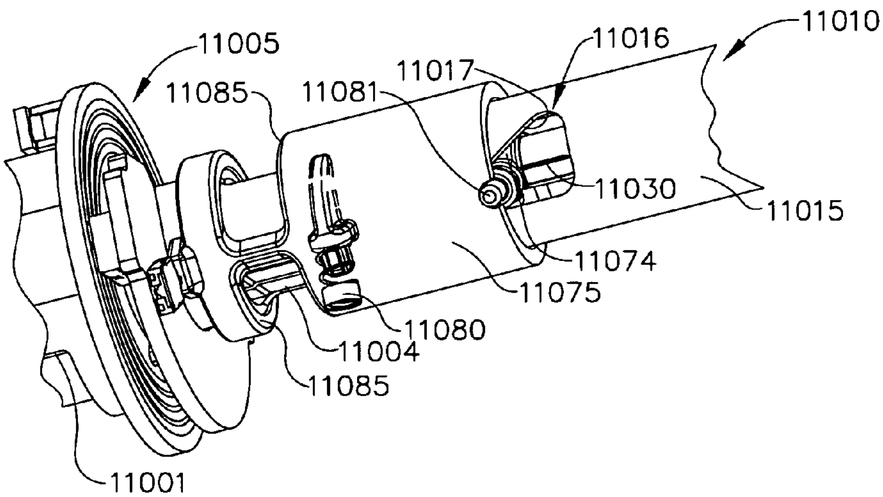



FIG. 144

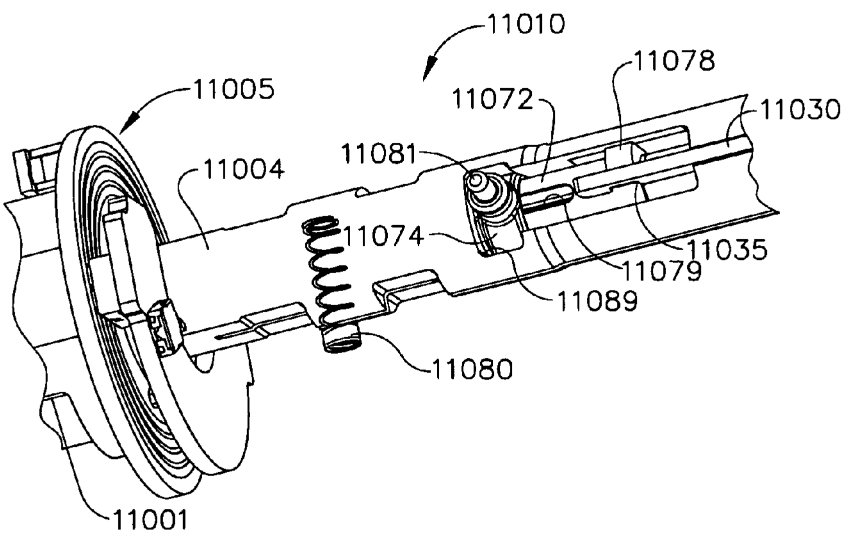



FIG. 145

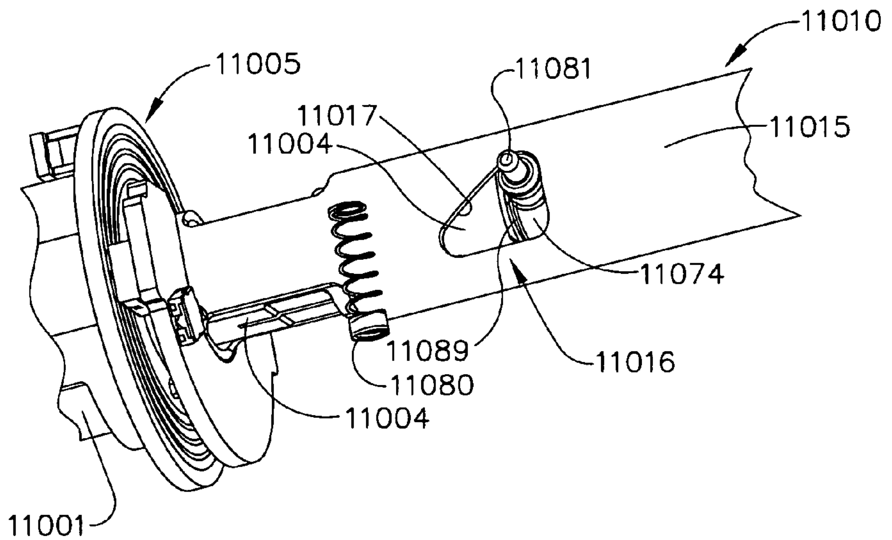



FIG. 146

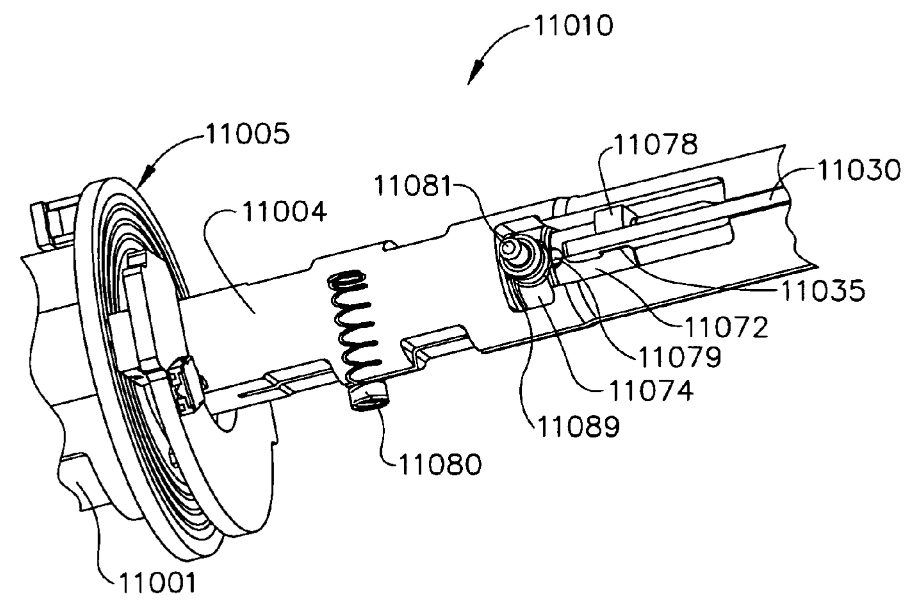



FIG. 147

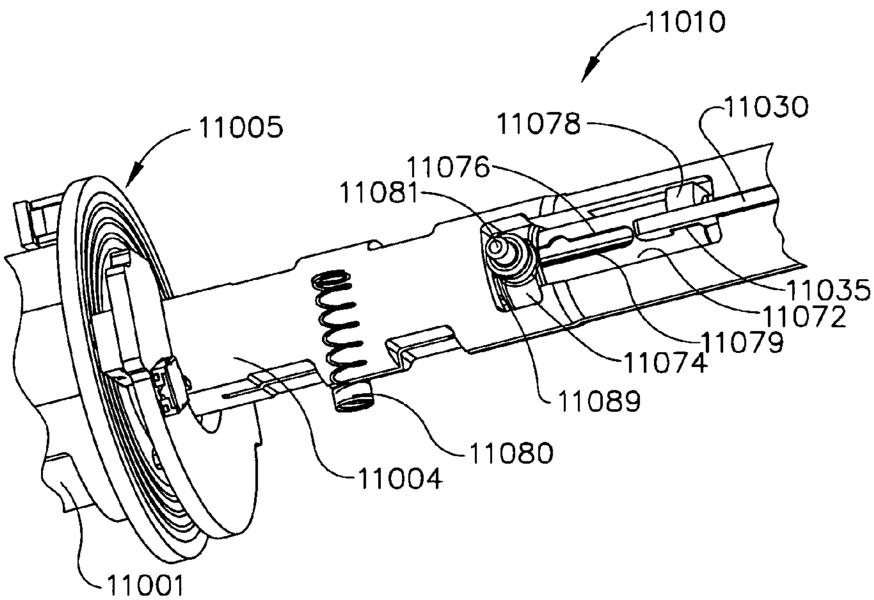



FIG. 148

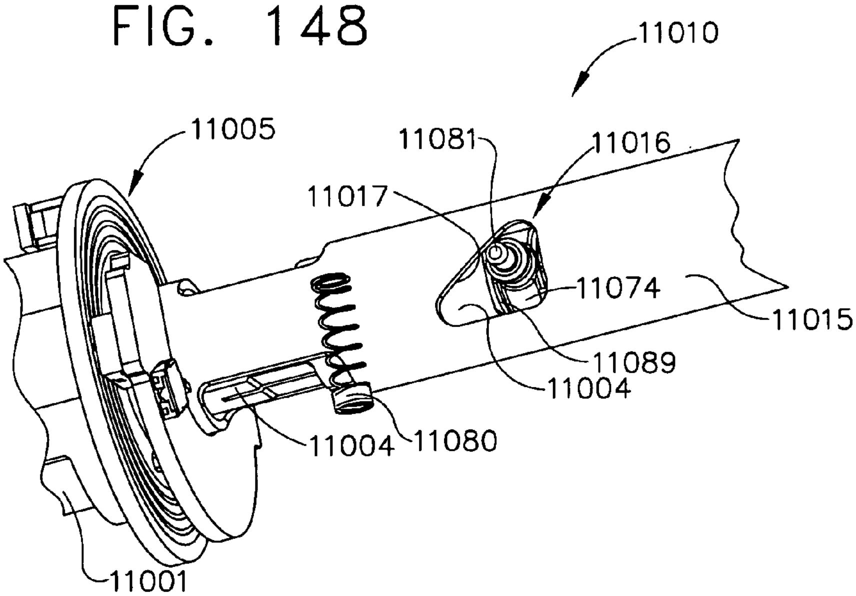



FIG. 149

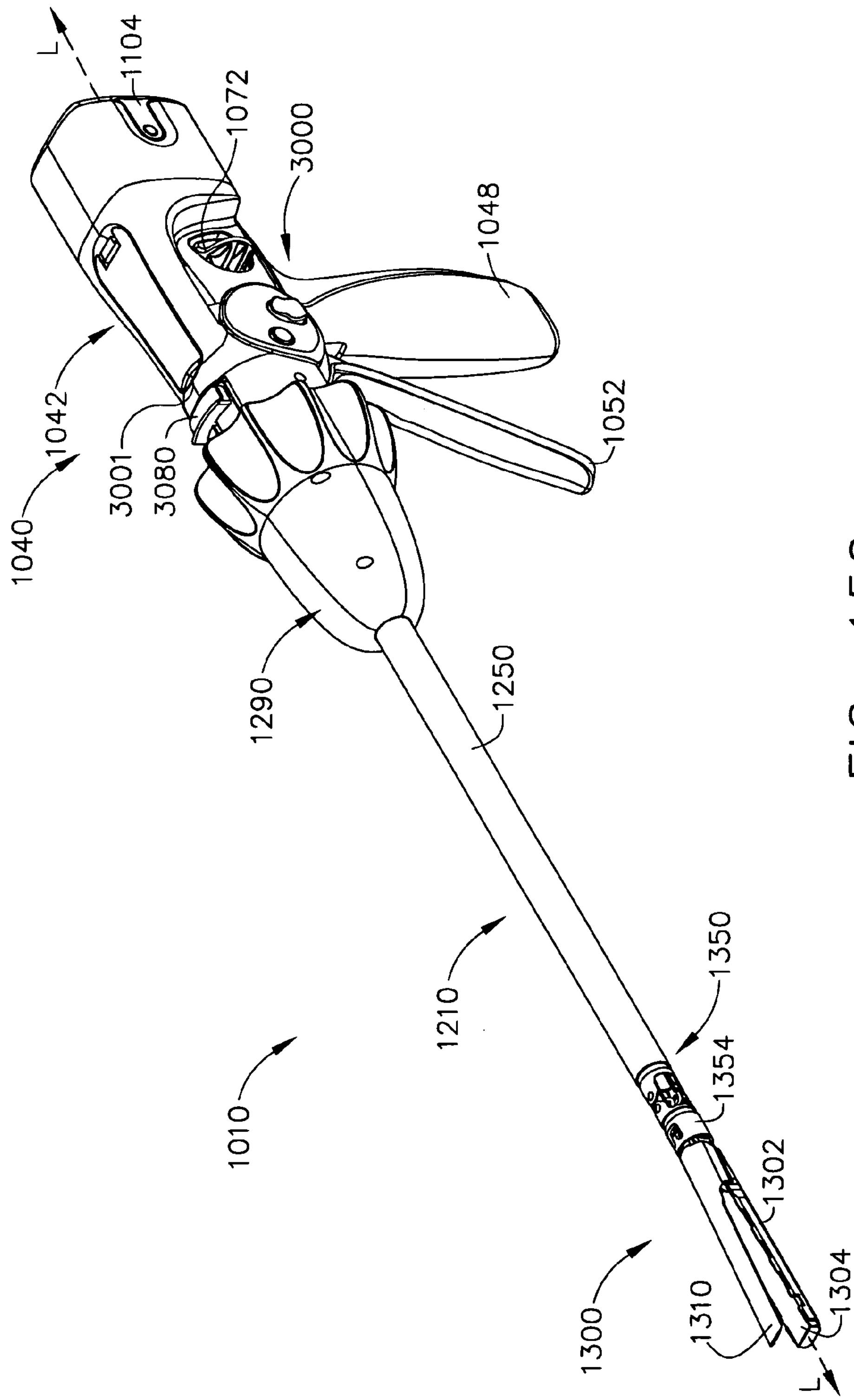
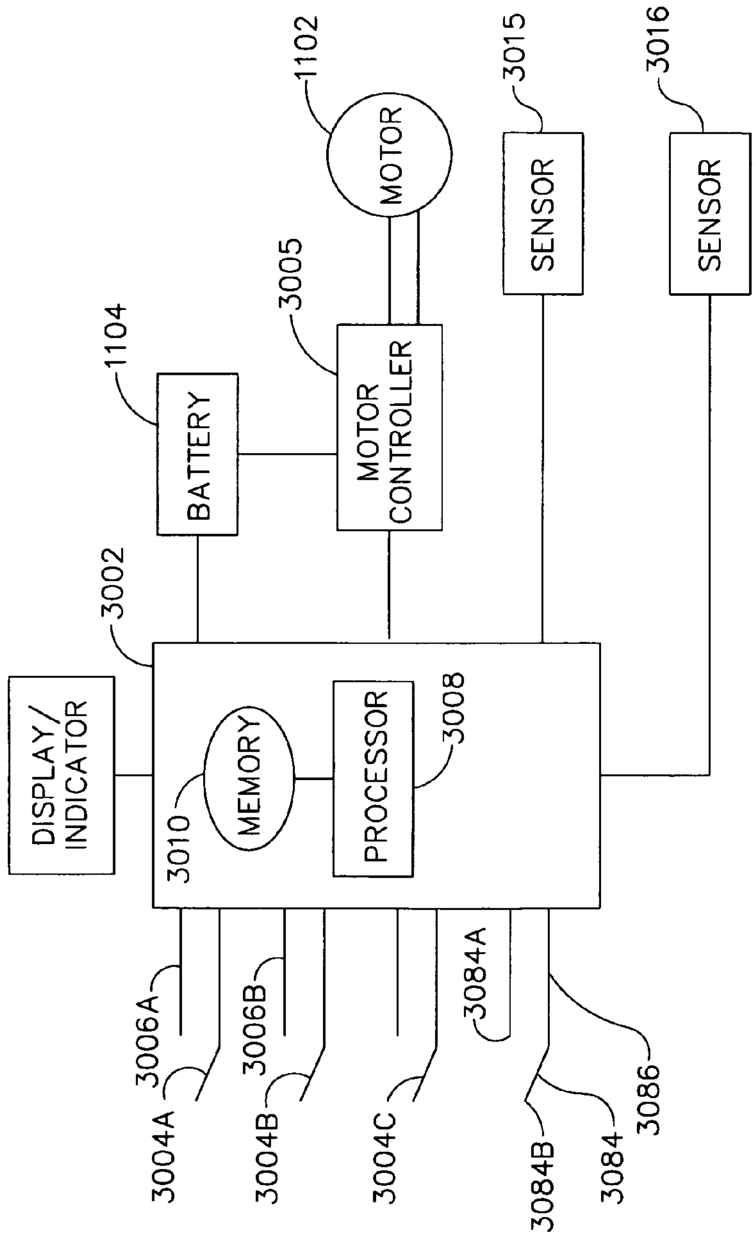

L
1104
1072
3000
1048
1042
1040
3001
3080
1052
1290
1250
1210
1010
1350
1354
1302
1300
1310
1304
L

FIG. 150



1102
MOTOR
3015
SENSOR
3016
SENSOR
3005
MOTOR CONTROLLER
1104
BATTERY
3002
DISPLAY/ INDICATOR
MEMORY
3010
PROCESSOR
3008
3006A
3004A
3006B
3004B
3004C
3084A
3084B
3084
3086


FIG. 151

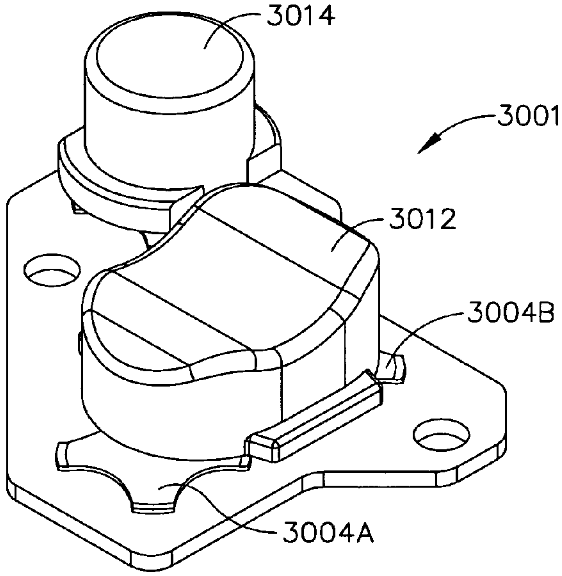



FIG. 152

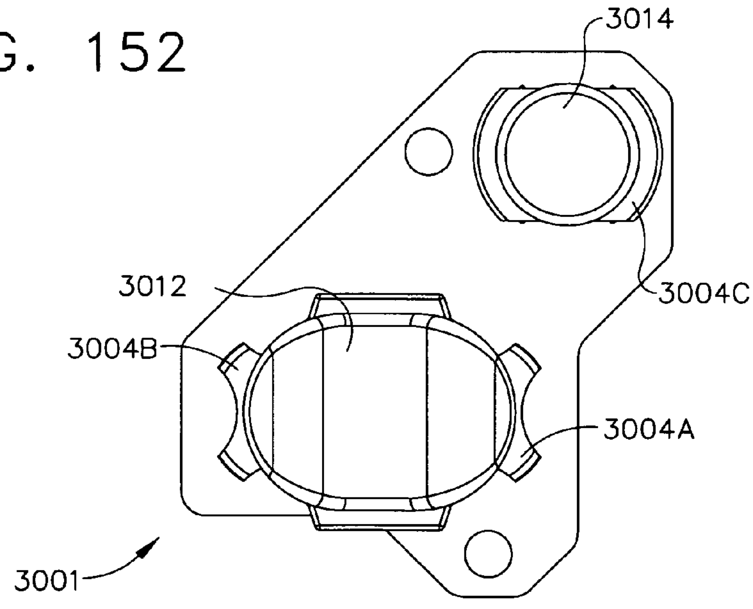



FIG. 153

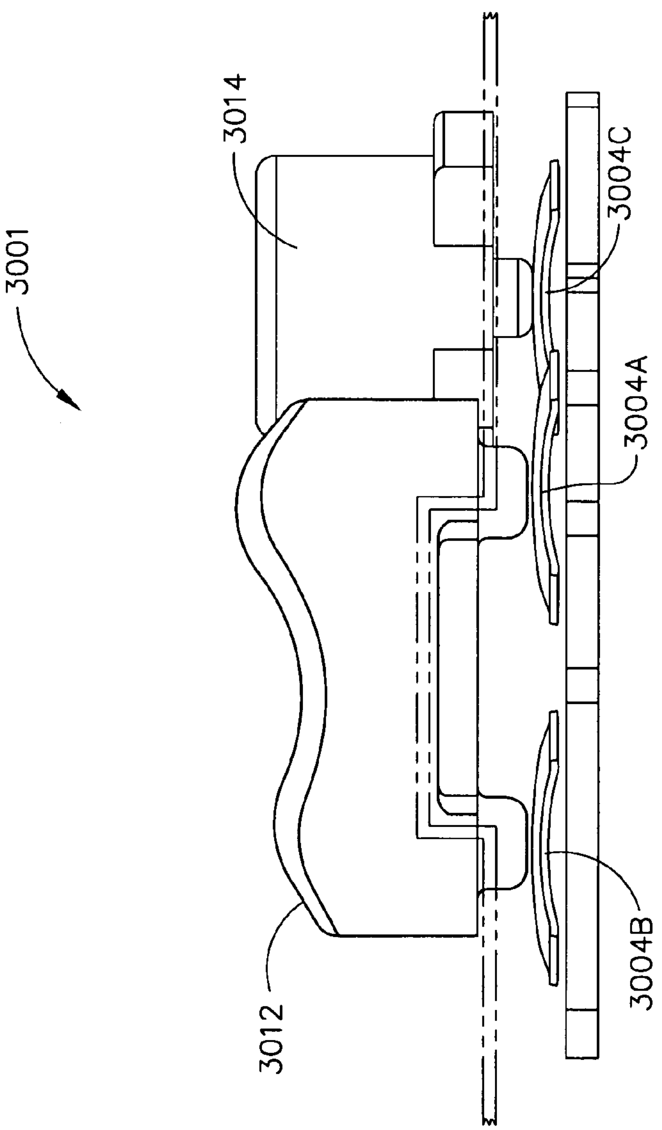



FIG. 154

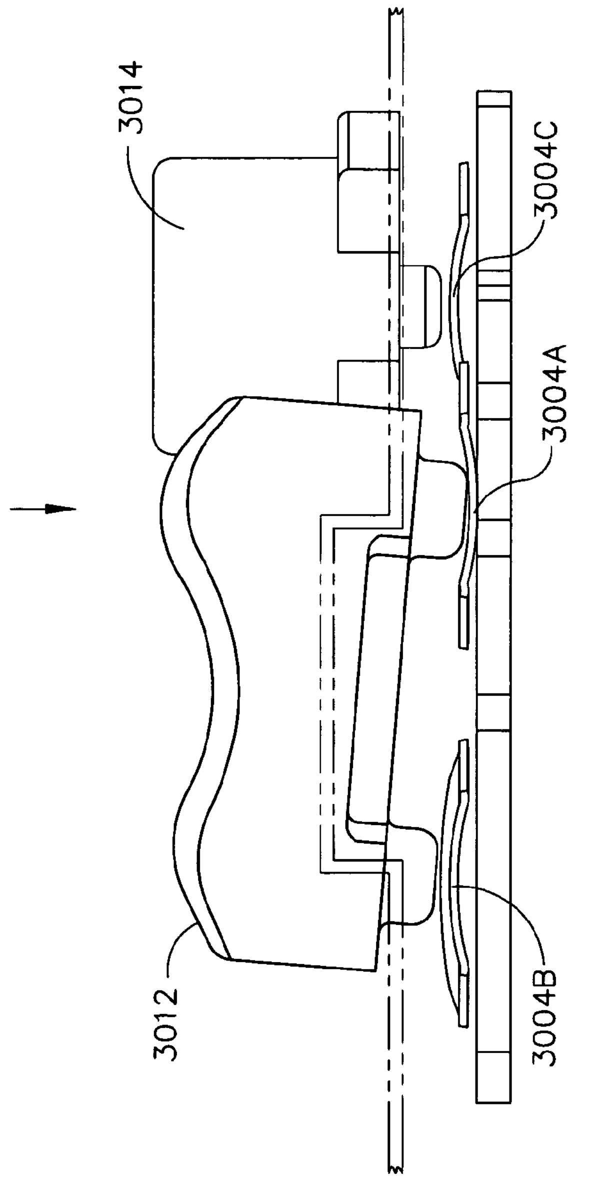



FIG. 155

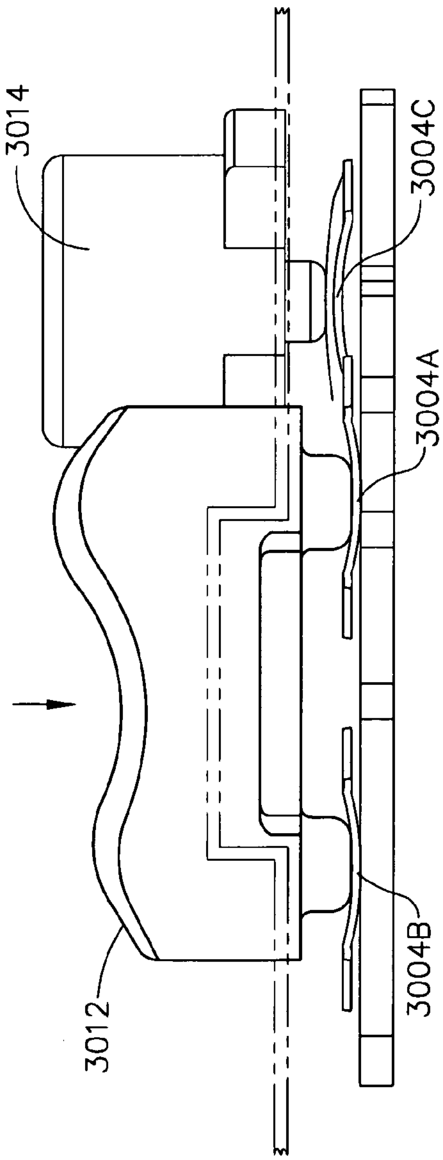



FIG. 156

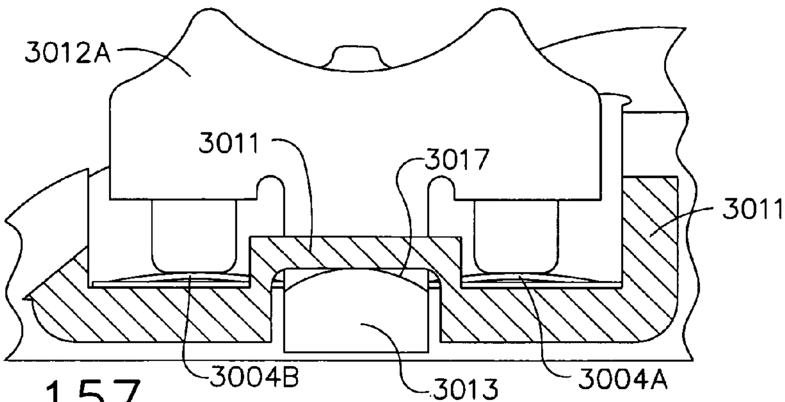



FIG. 157

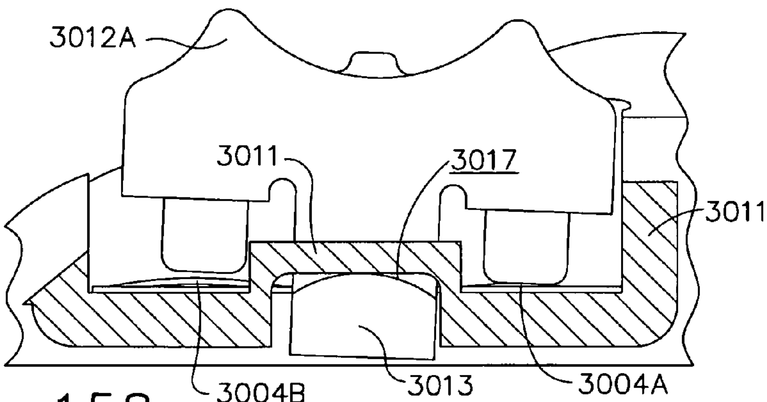



FIG. 158

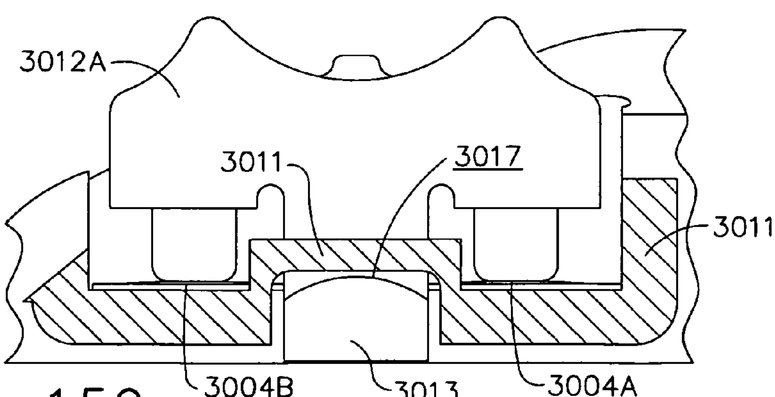



FIG. 159

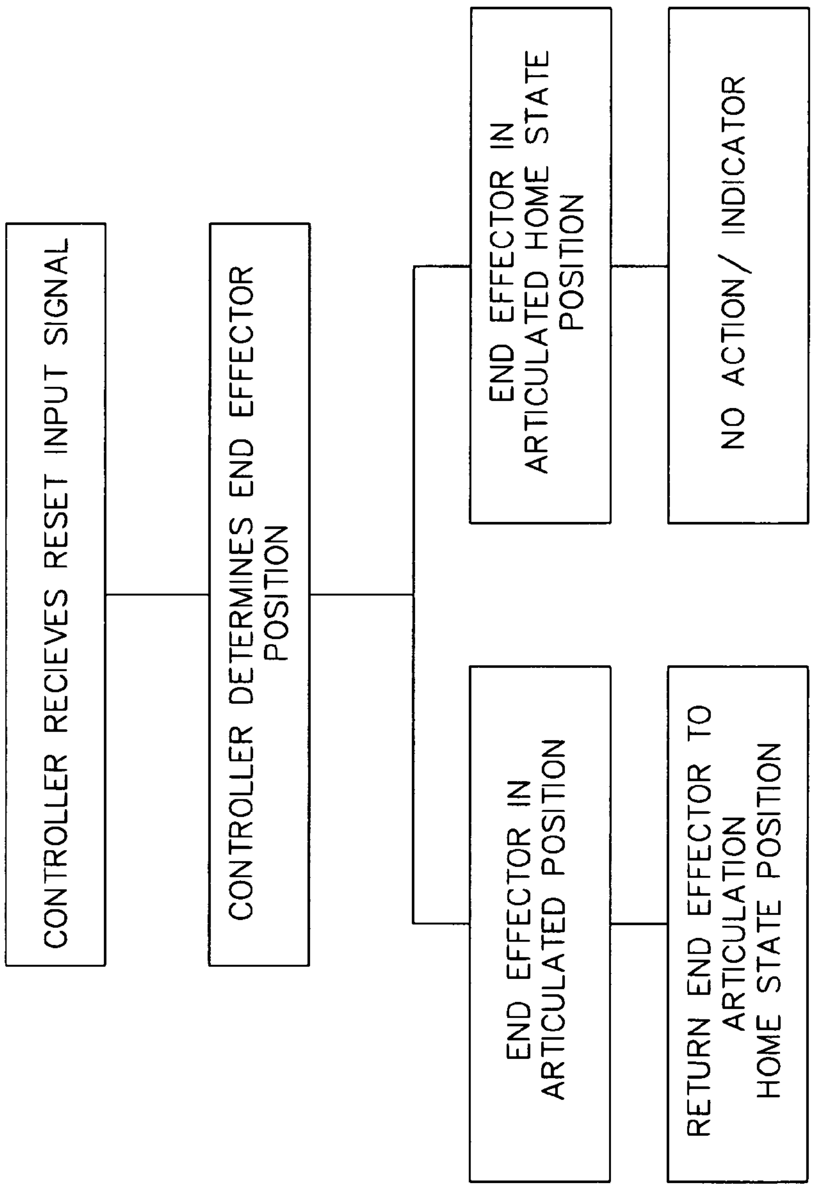

CONTROLLER RECIEVES RESET INPUT SIGNAL
CONTROLLER DETERMINES END EFFECTOR POSITION
END EFFECTOR IN ARTICULATED HOME STATE POSITION
NO ACTION/ INDICATOR
END EFFECTOR IN ARTICULATED POSITION
RETURN END EFFECTOR TO ARTICULATION HOME STATE POSITION

FIG. 160

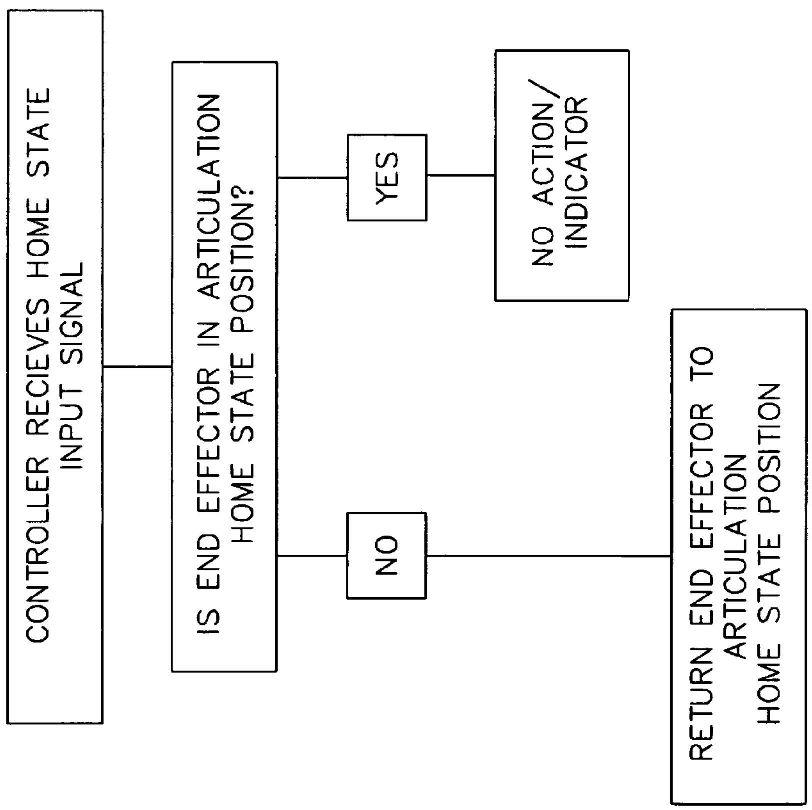

CONTROLLER RECIEVES HOME STATE INPUT SIGNAL
IS END EFFECTOR IN ARTICULATION HOME STATE POSITION?
YES
NO ACTION/ INDICATOR
NO
RETURN END EFFECTOR TO ARTICULATION HOME STATE POSITION

FIG. 161

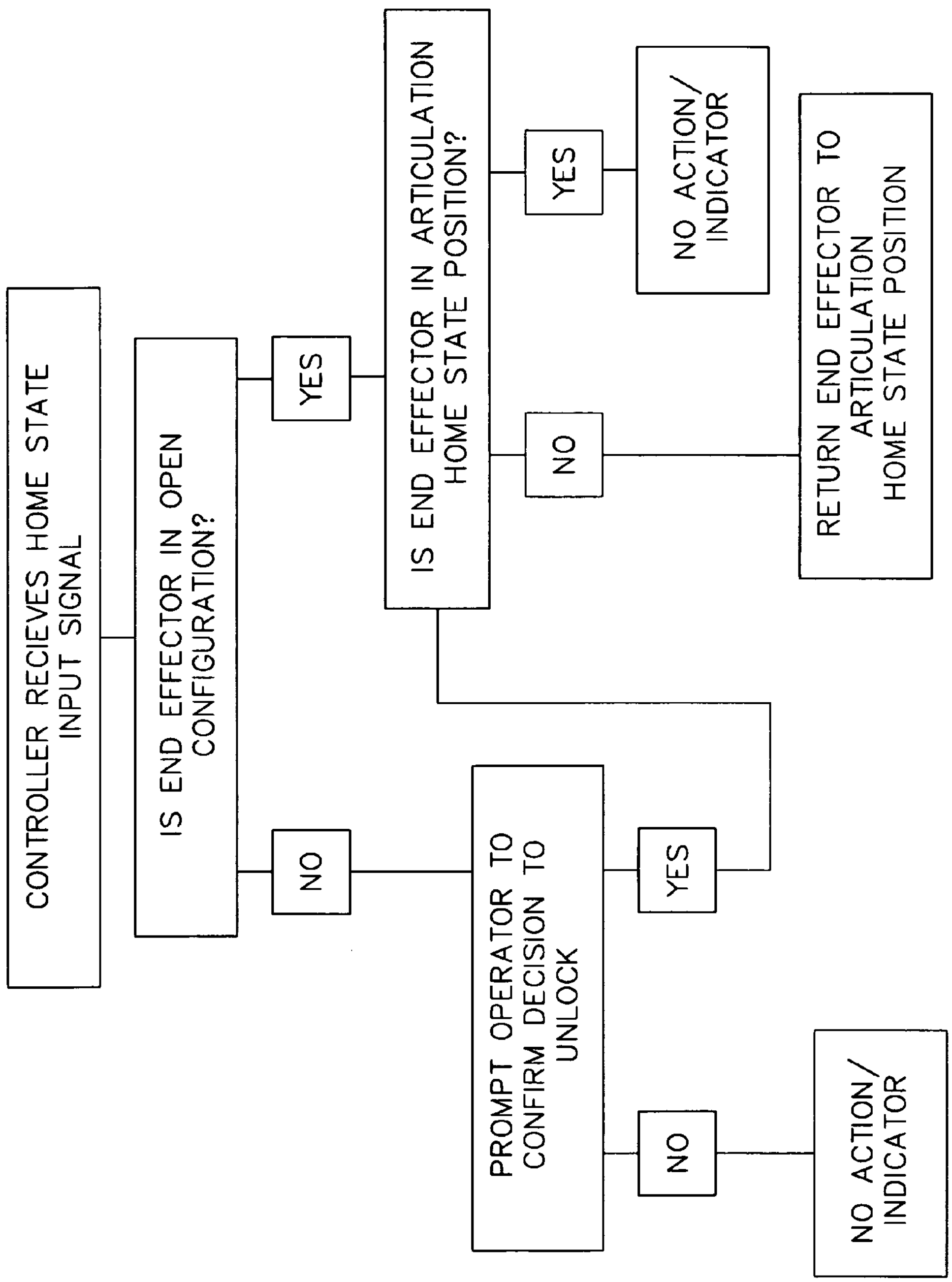

CONTROLLER RECIEVES HOME STATE INPUT SIGNAL
IS END EFFECTOR IN OPEN CONFIGURATION?
YES
NO
IS END EFFECTOR IN ARTICULATION HOME STATE POSITION?
YES
NO ACTION/ INDICATOR
NO
RETURN END EFFECTOR TO ARTICULATION HOME STATE POSITION
PROMPT OPERATOR TO CONFIRM DECISION TO UNLOCK
YES
NO
NO ACTION/ INDICATOR

FIG. 162

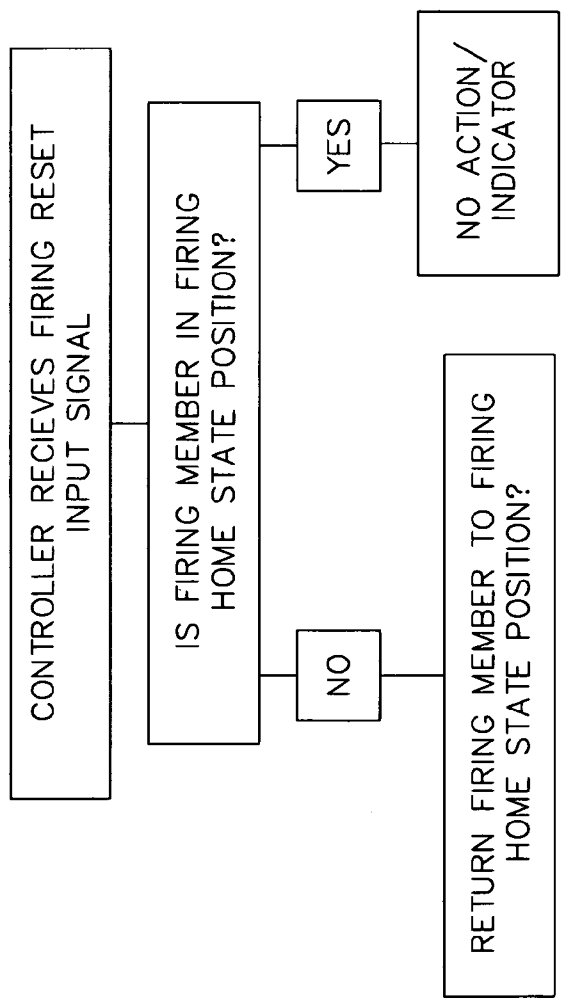
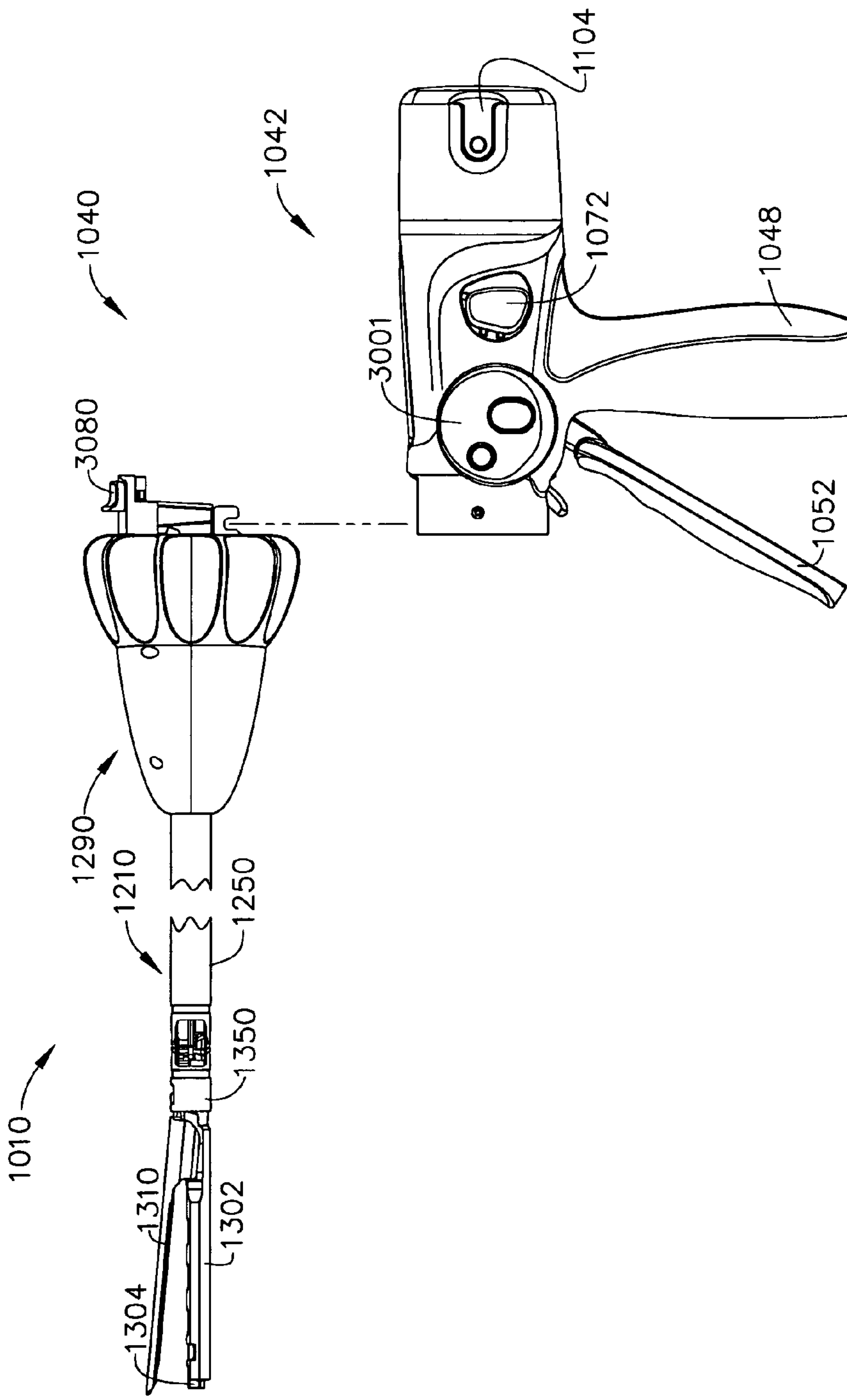

CONTROLLER RECIEVES FIRING RESET INPUT SIGNAL
IS FIRING MEMBER IN FIRING HOME STATE POSITION?
YES
NO ACTION/ INDICATOR
NO
RETURN FIRING MEMBER TO FIRING HOME STATE POSITION?

FIG. 163


1104
1042
1040
1072
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3001
3080
1052
1290
1210
1250
1350
1010
1310
1302
1304

FIG. 164

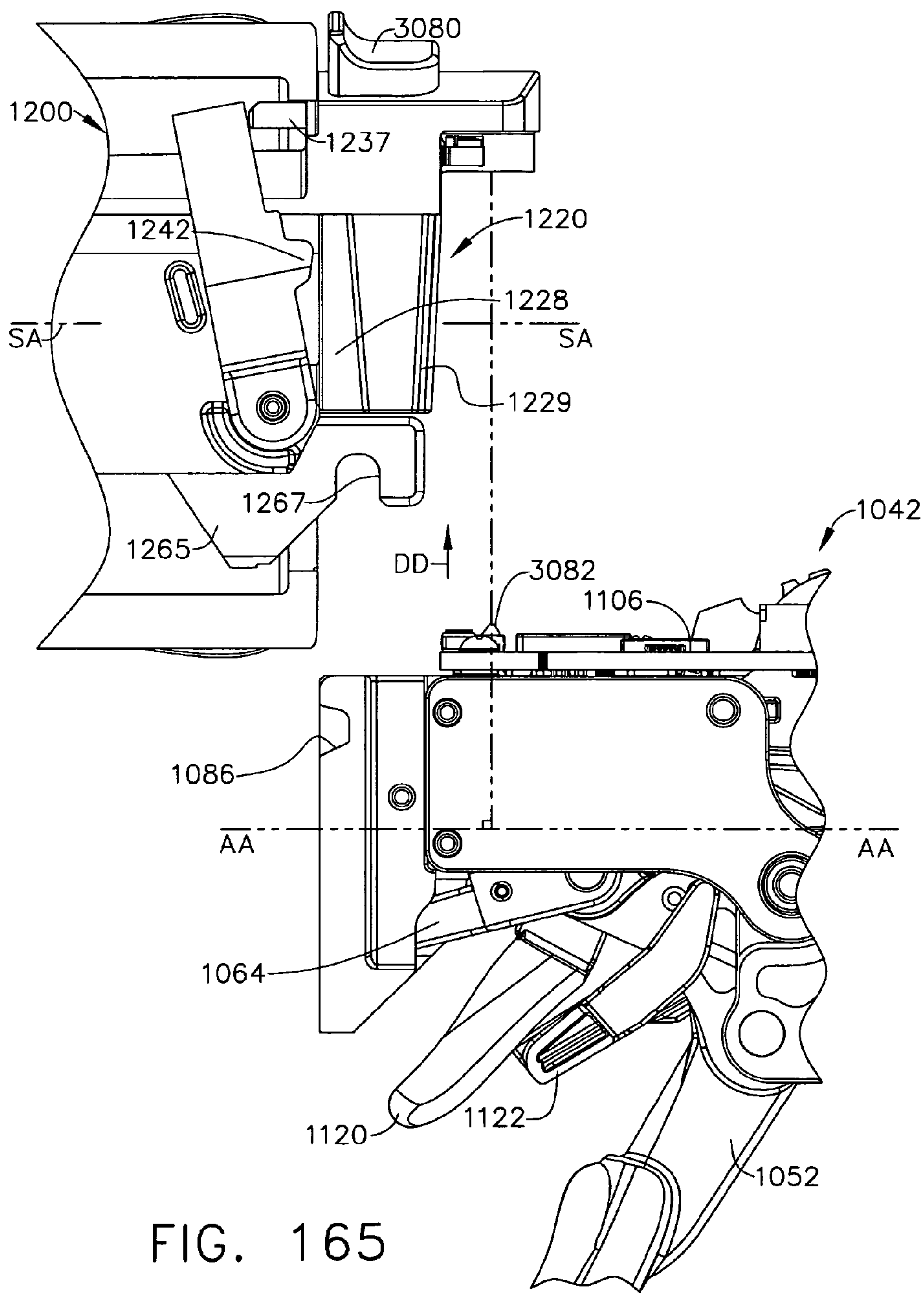

3080
1200
1237
1220
1242
1228
SA
SA
1229
1267
1042
1265
DD
3082
1106
1086
AA
AA
1064
1120
1122
1052

FIG. 165

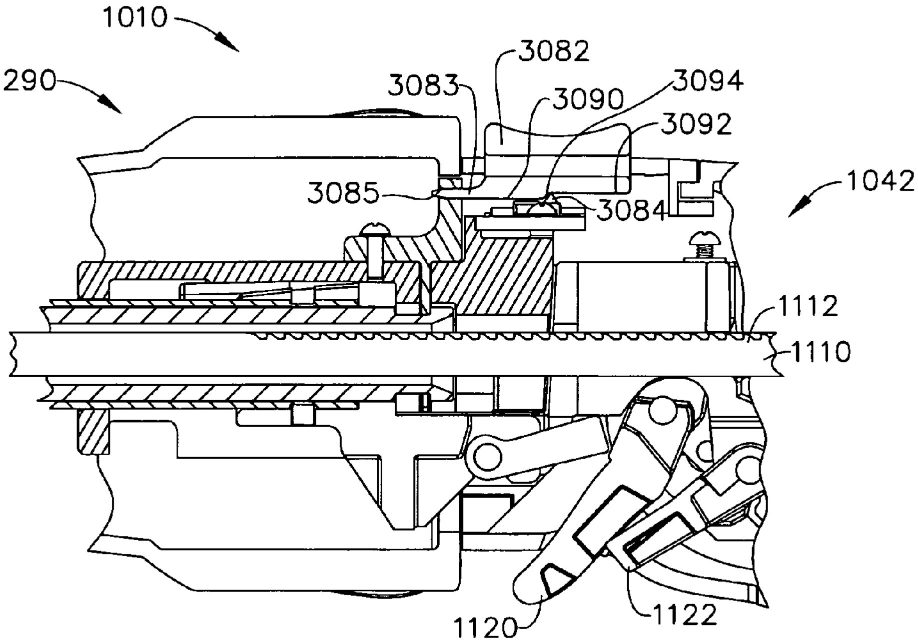



FIG. 166

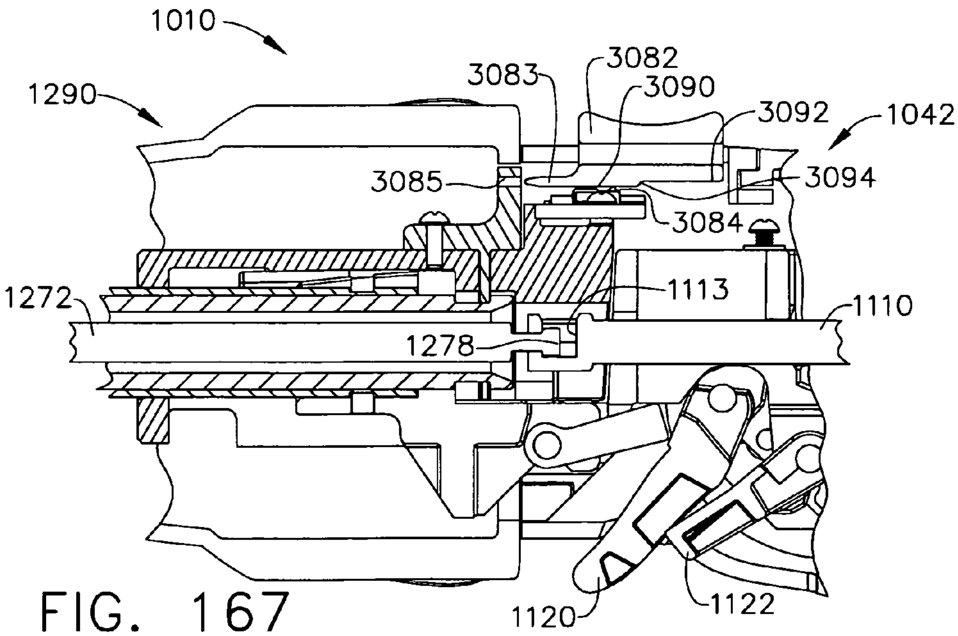



FIG. 167

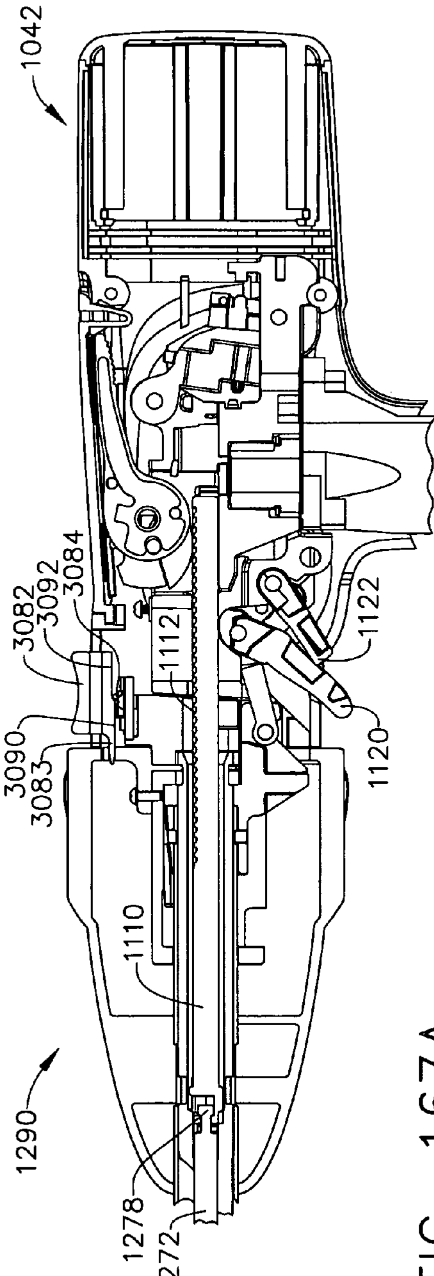



FIG. 167A

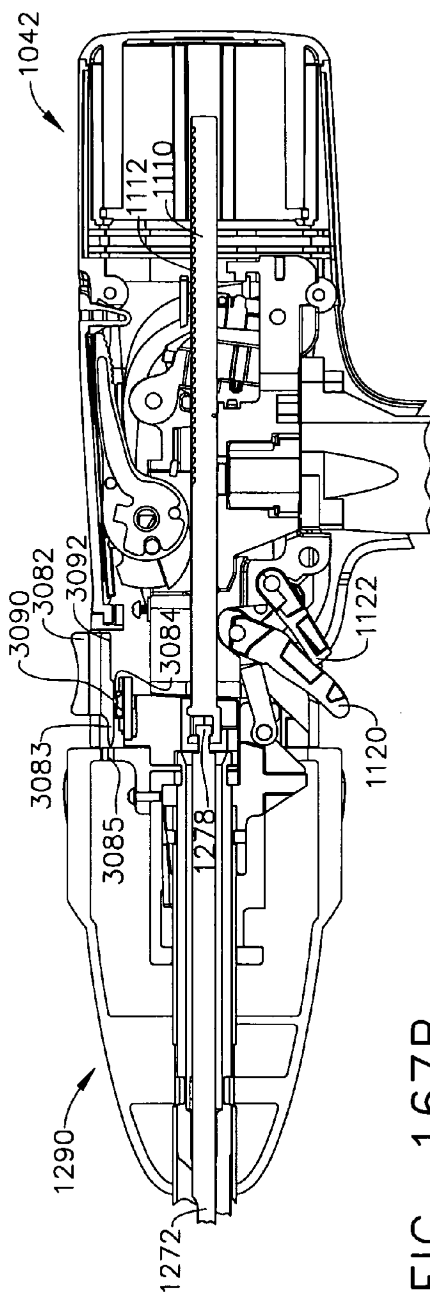



FIG. 167B

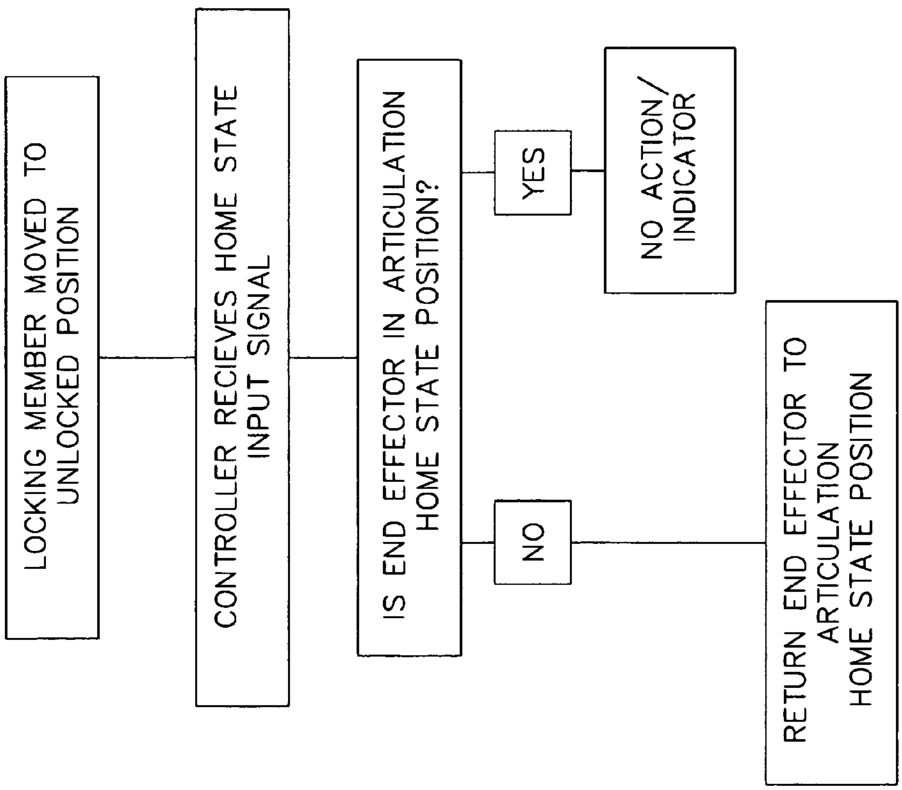
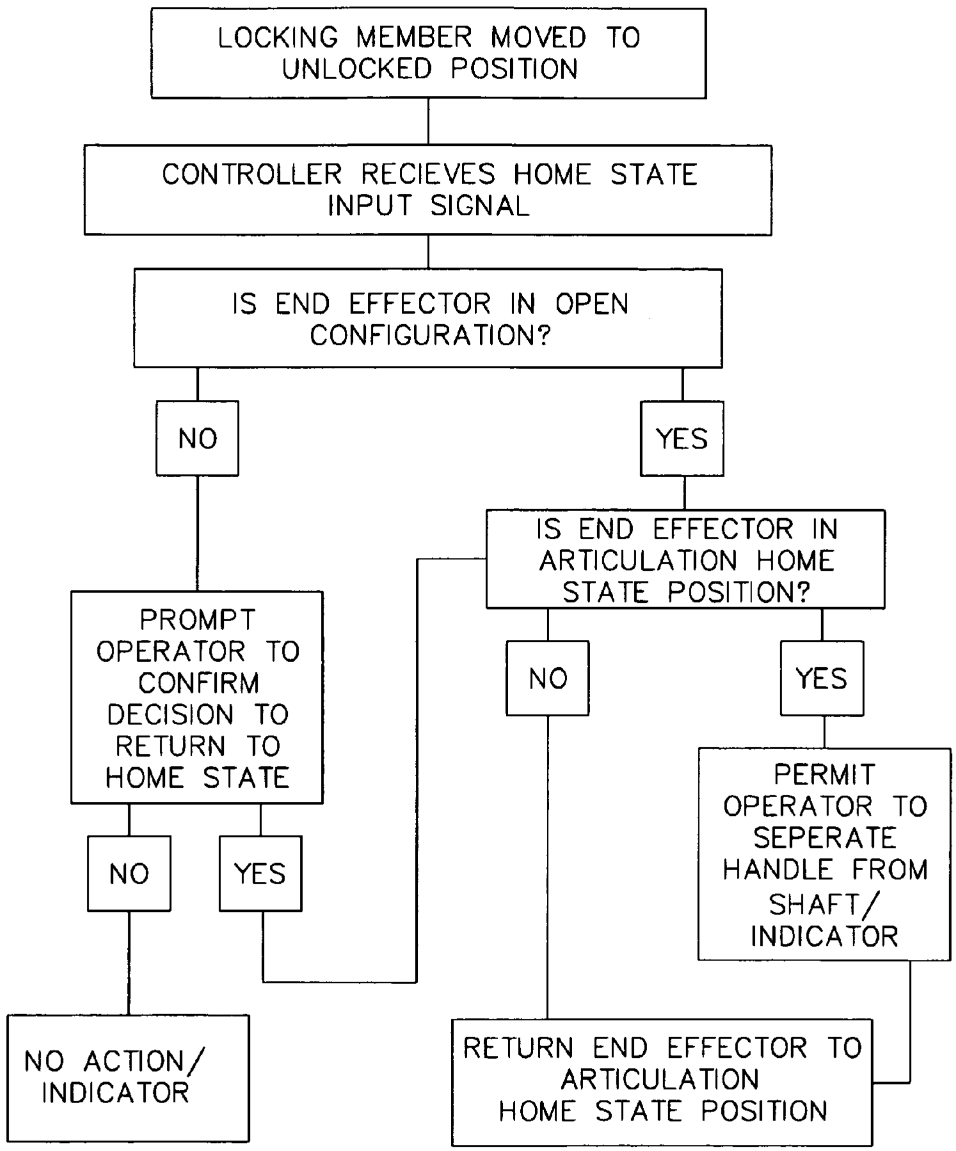

LOCKING MEMBER MOVED TO UNLOCKED POSITION
CONTROLLER RECIEVES HOME STATE INPUT SIGNAL
IS END EFFECTOR IN ARTICULATION HOME STATE POSITION?
YES
NO ACTION/ INDICATOR
NO
RETURN END EFFECTOR TO ARTICULATION HOME STATE POSITION

FIG. 168



LOCKING MEMBER MOVED TO UNLOCKED POSITION
CONTROLLER RECIEVES HOME STATE INPUT SIGNAL
IS END EFFECTOR IN OPEN CONFIGURATION?
NO
YES
IS END EFFECTOR IN ARTICULATION HOME STATE POSITION?
PROMPT OPERATOR TO CONFIRM DECISION TO RETURN TO HOME STATE
NO
YES
PERMIT OPERATOR TO SEPERATE HANDLE FROM SHAFT/ INDICATOR
NO
YES
NO ACTION/ INDICATOR
RETURN END EFFECTOR TO ARTICULATION HOME STATE POSITION


FIG. 169

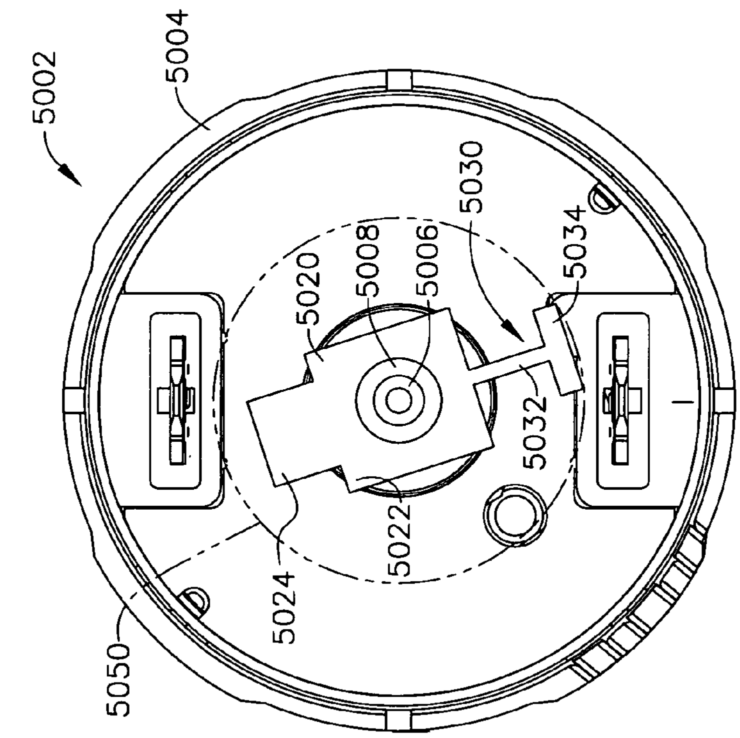



FIG. 170

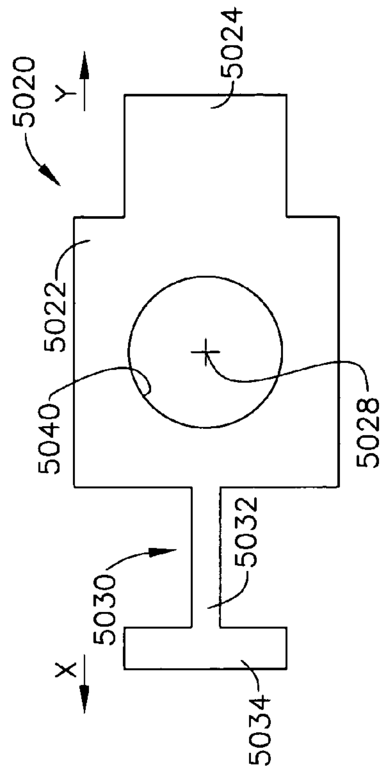



FIG. 172

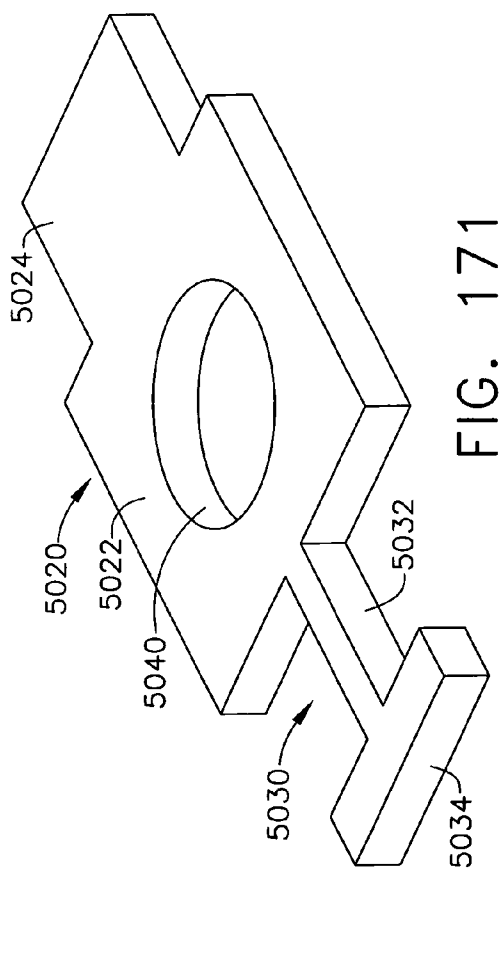



FIG. 171

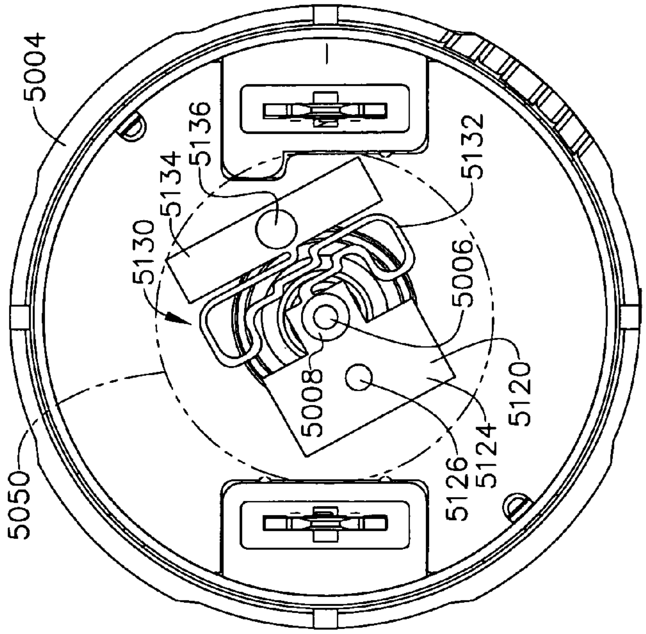



FIG. 174

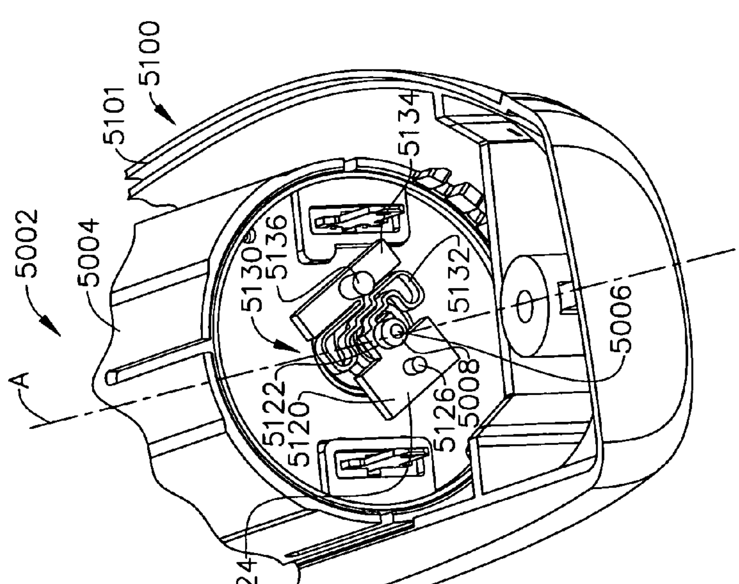



FIG. 173

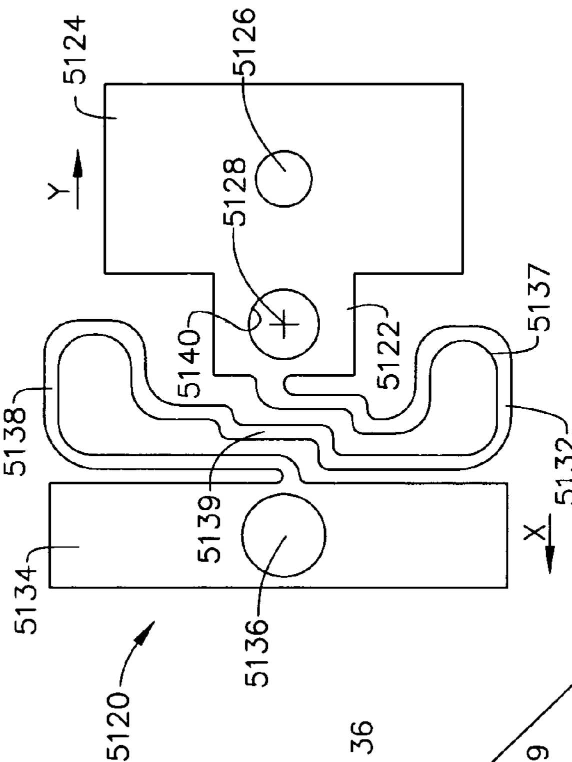



FIG. 176

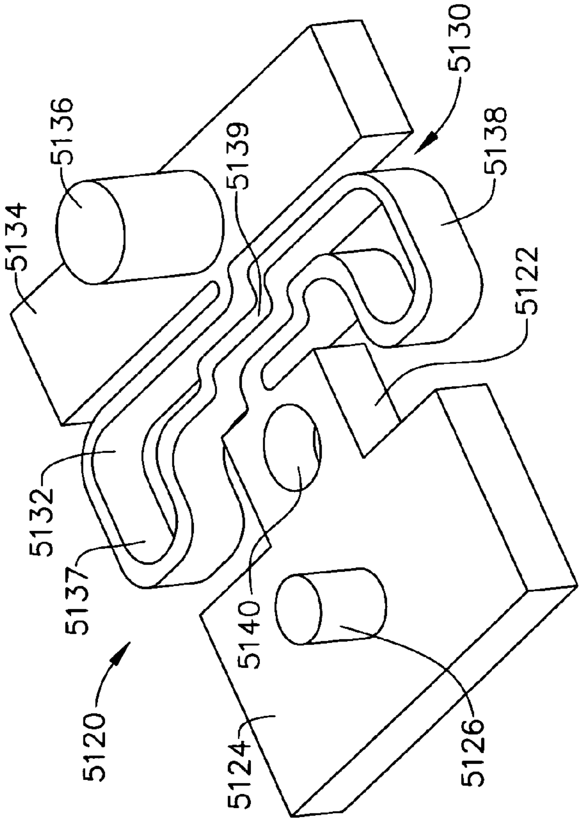



FIG. 175

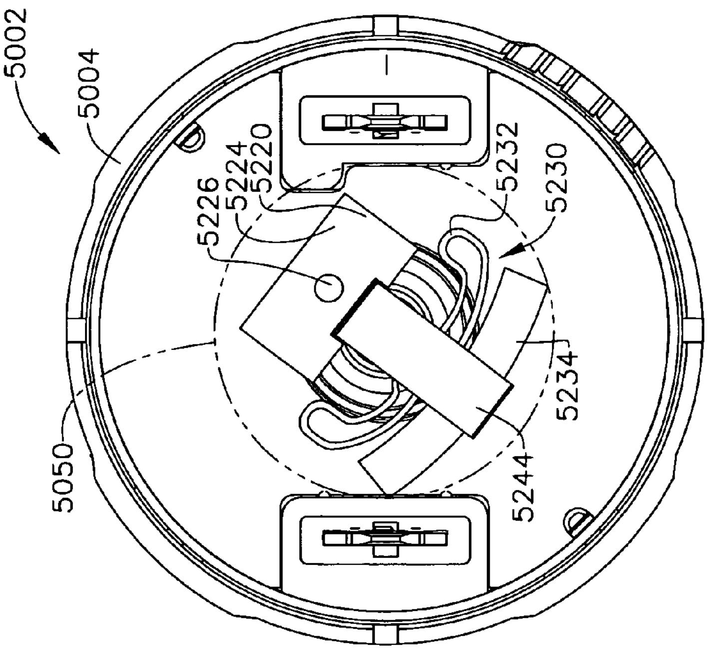



FIG. 178

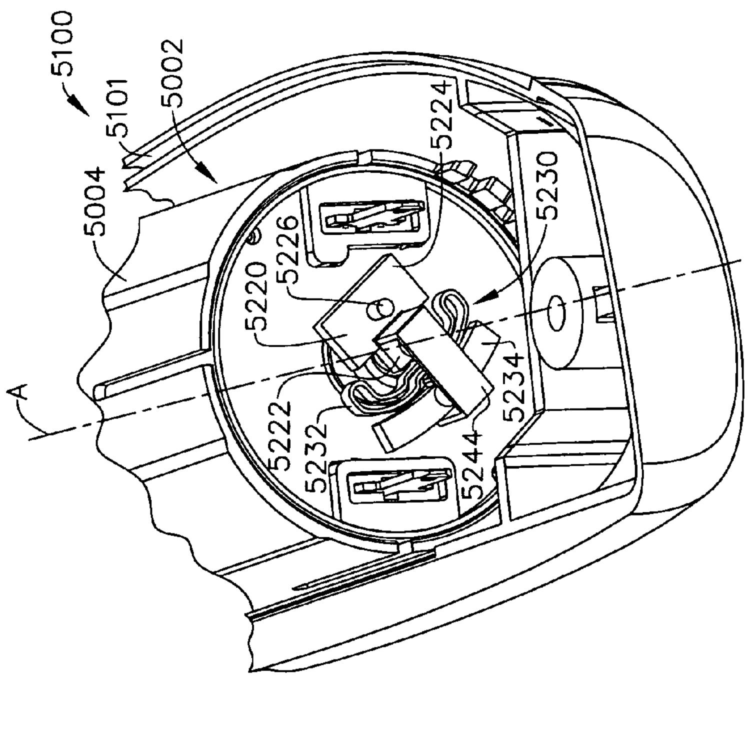



FIG. 177

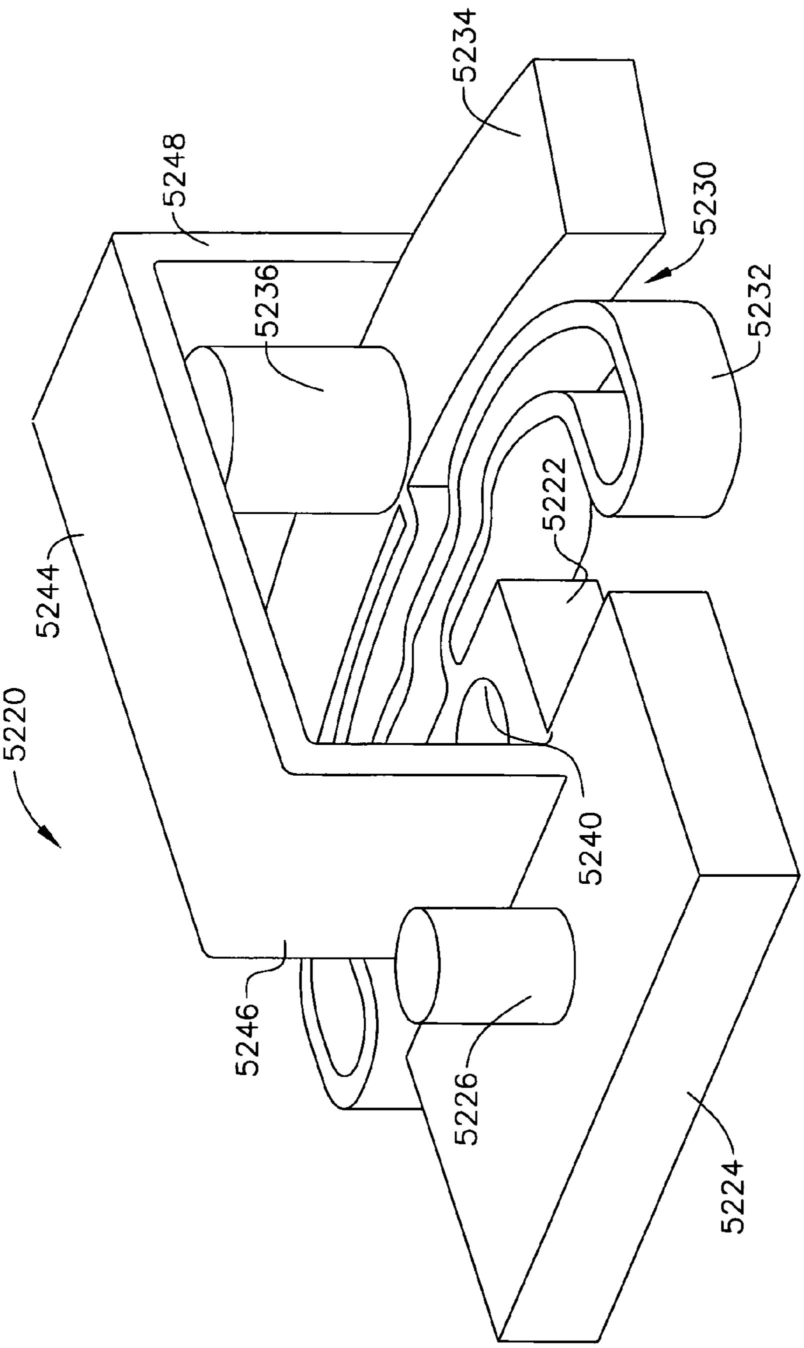



FIG. 179

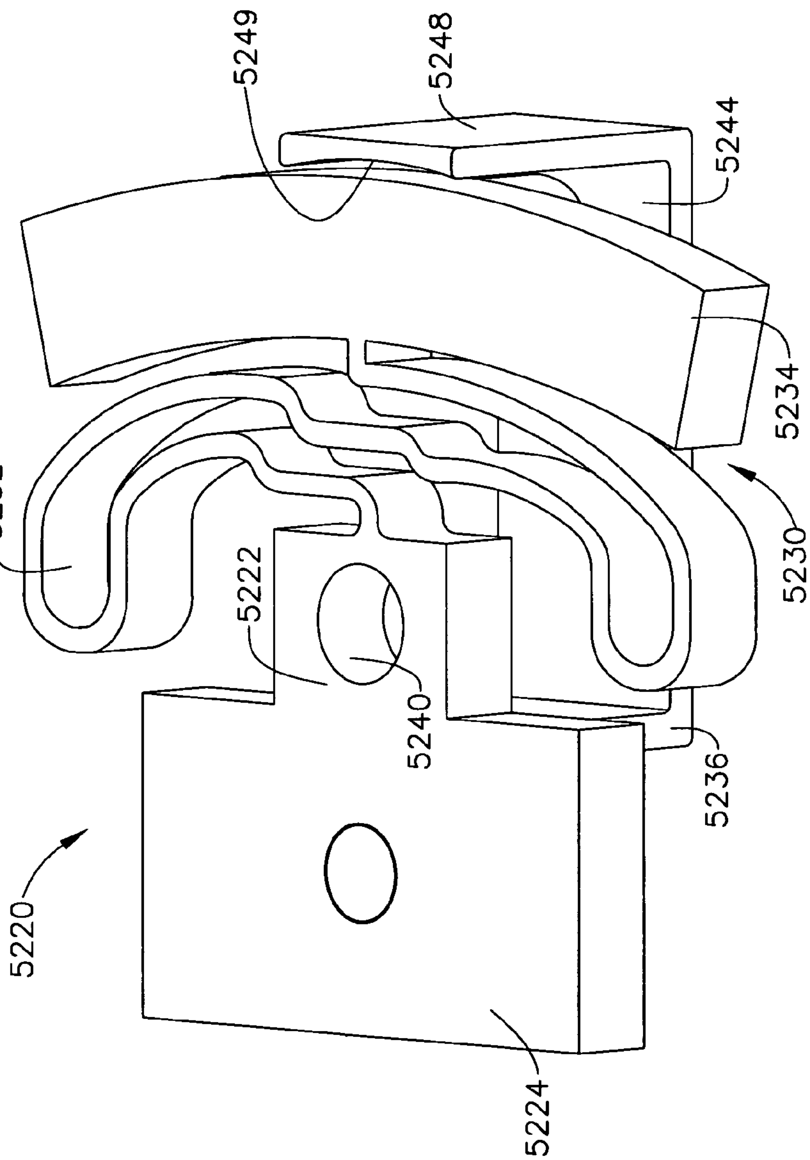



FIG. 180

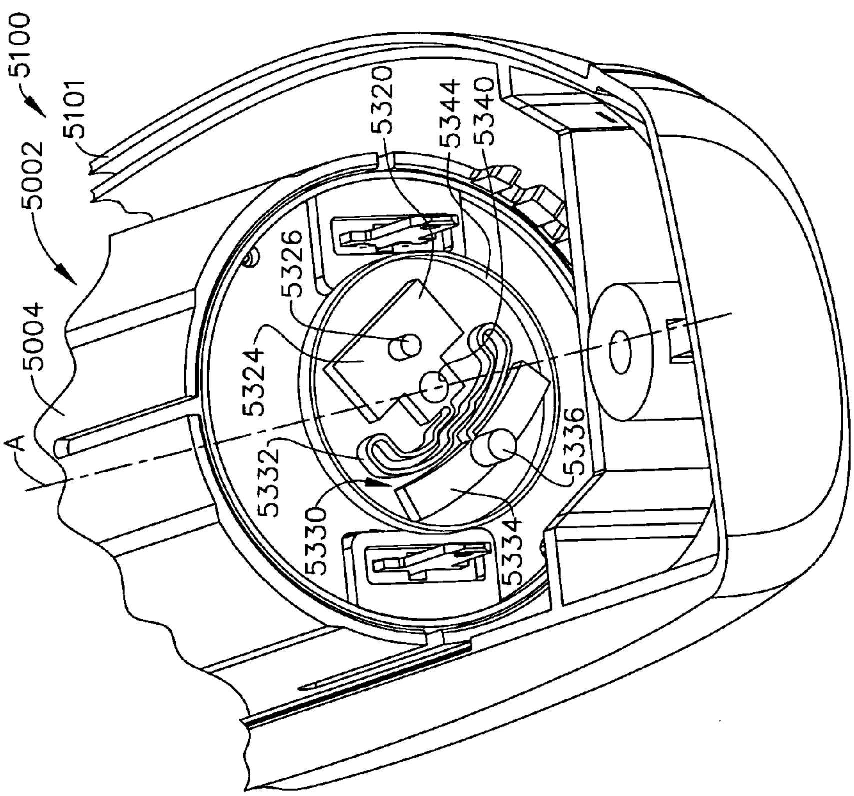

5100
5101
5002
5004
A
5320
5344
5340
5326
5324
5332
5330
5334
5336

FIG. 181

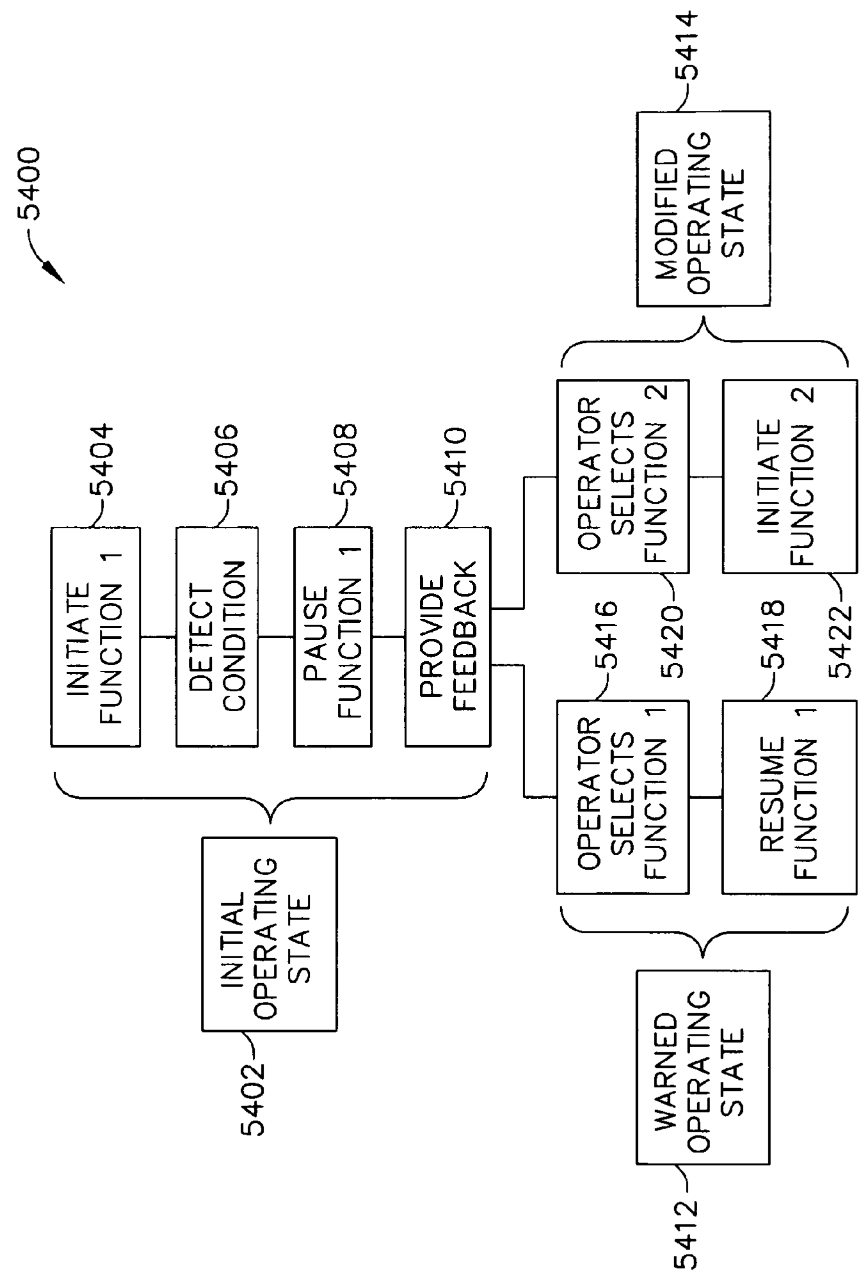

5400
INITIAL OPERATING STATE
5402
INITIATE FUNCTION 1
5404
DETECT CONDITION
5406
PAUSE FUNCTION 1
5408
PROVIDE FEEDBACK
5410
OPERATOR SELECTS FUNCTION 1
5416
RESUME FUNCTION 1
5418
OPERATOR SELECTS FUNCTION 2
5420
INITIATE FUNCTION 2
5422
WARNED OPERATING STATE
5412
MODIFIED OPERATING STATE
5414

FIG. 182

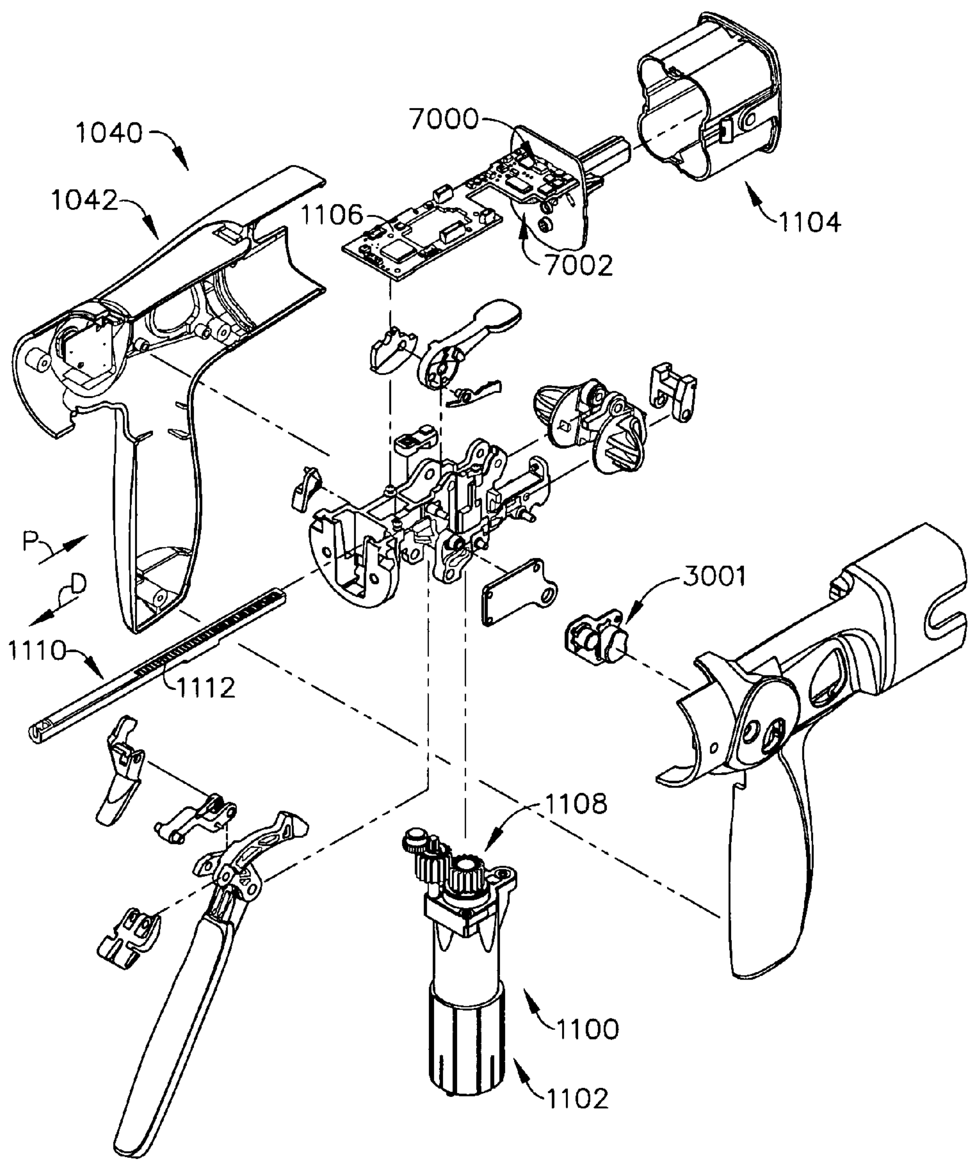

1040
1042
7000
1106
7002
1104
P
D
3001
1110
1112
1108
1100
1102

FIG. 183

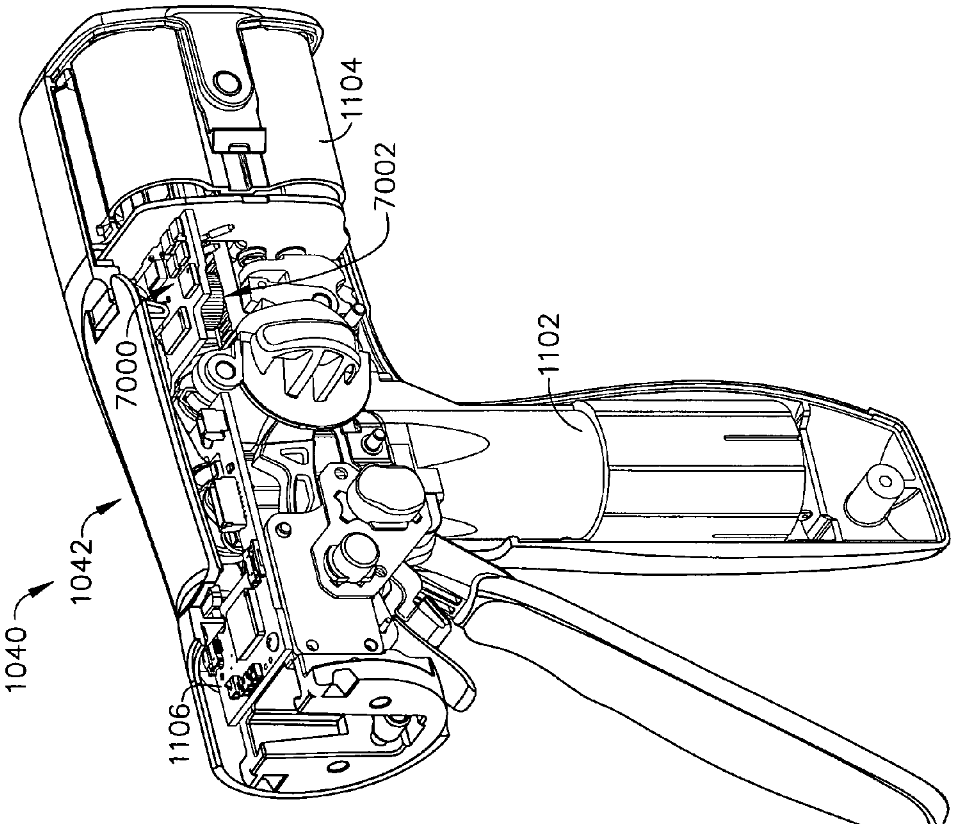



FIG. 184

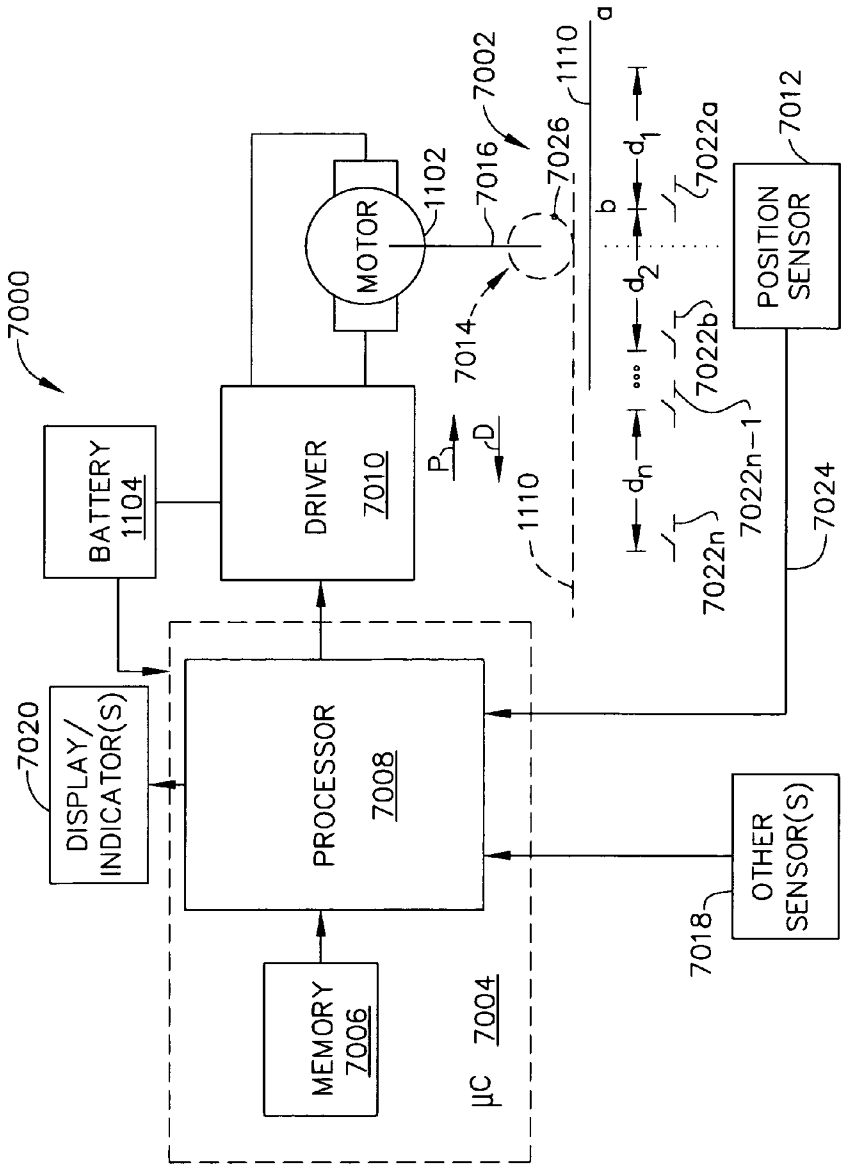

7000
BATTERY
1104
DRIVER
7010
MOTOR
1102
7016
7026
7002
1110
a
b
$d_1$
$d_2$
$d_n$
7014
P
D
1110
7022a
7022b
7022n-1
7022n
POSITION
SENSOR
7012
7024
DISPLAY/
INDICATOR(S)
7020
PROCESSOR
7008
OTHER
SENSOR(S)
7018
MEMORY
7006
μC 7004

FIG. 185

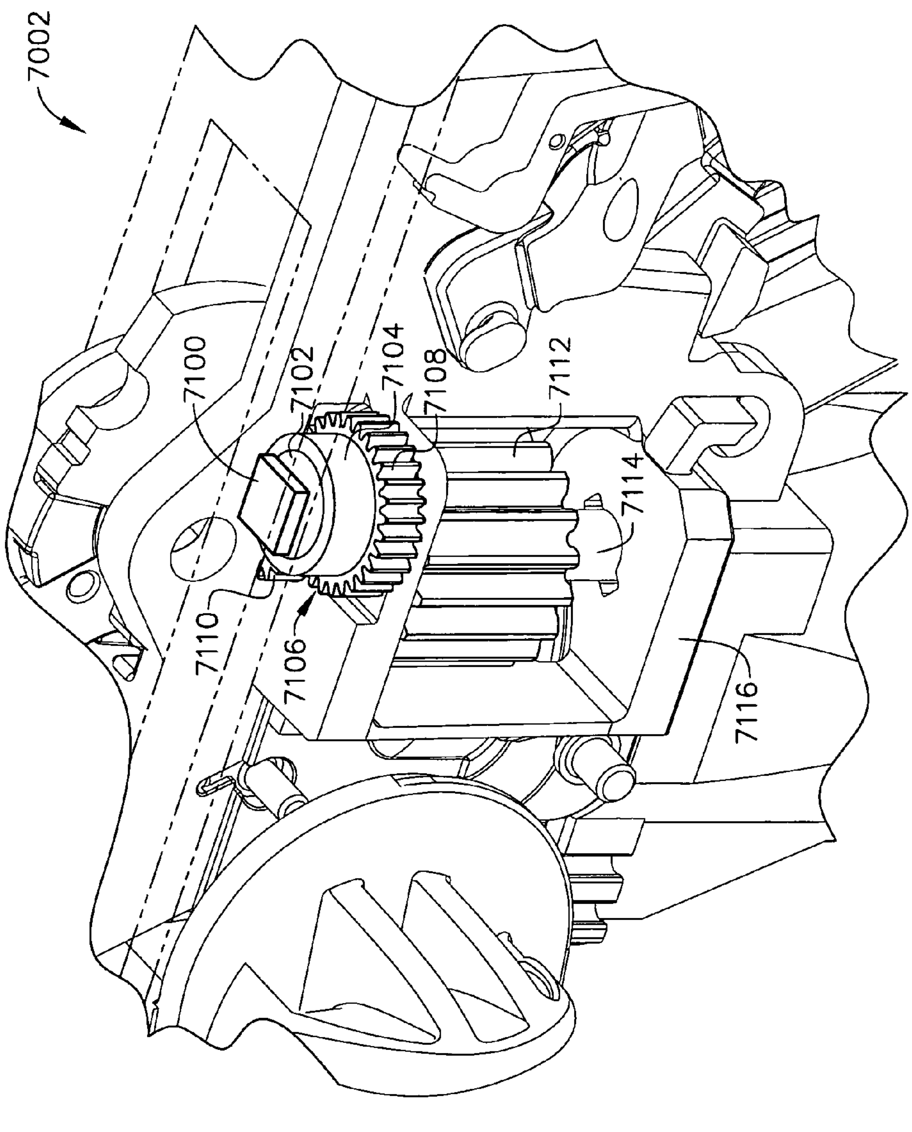



FIG. 186

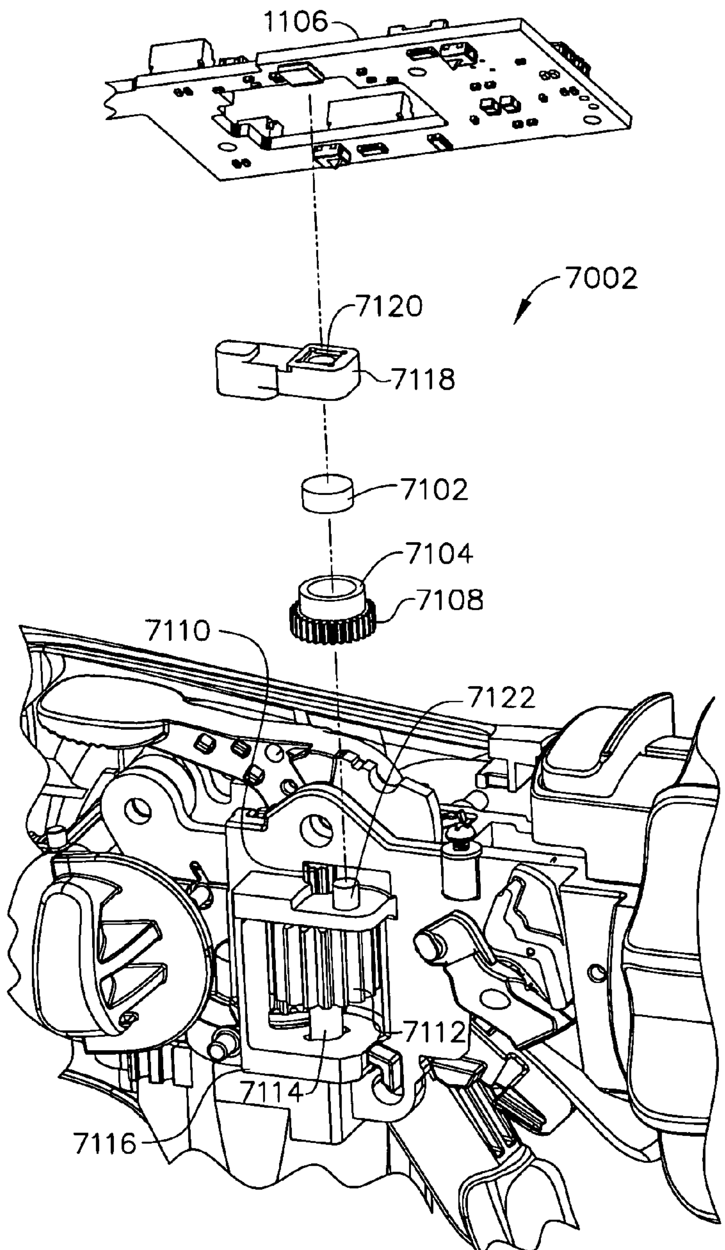



FIG. 187

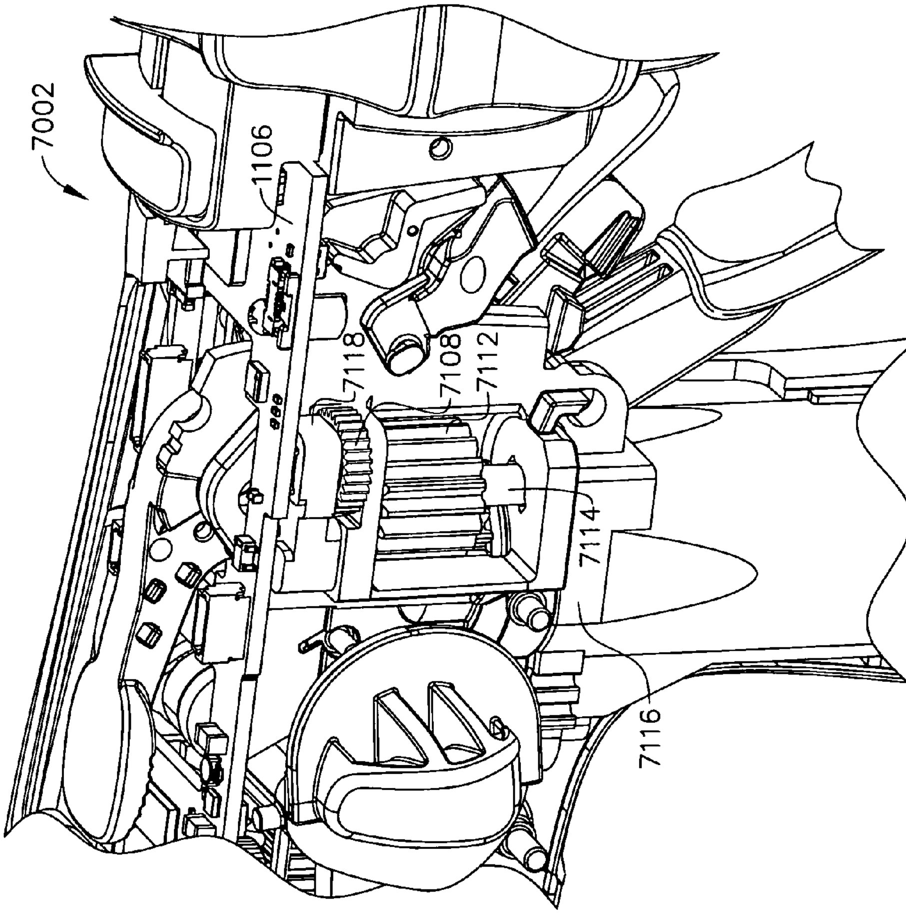



FIG. 188

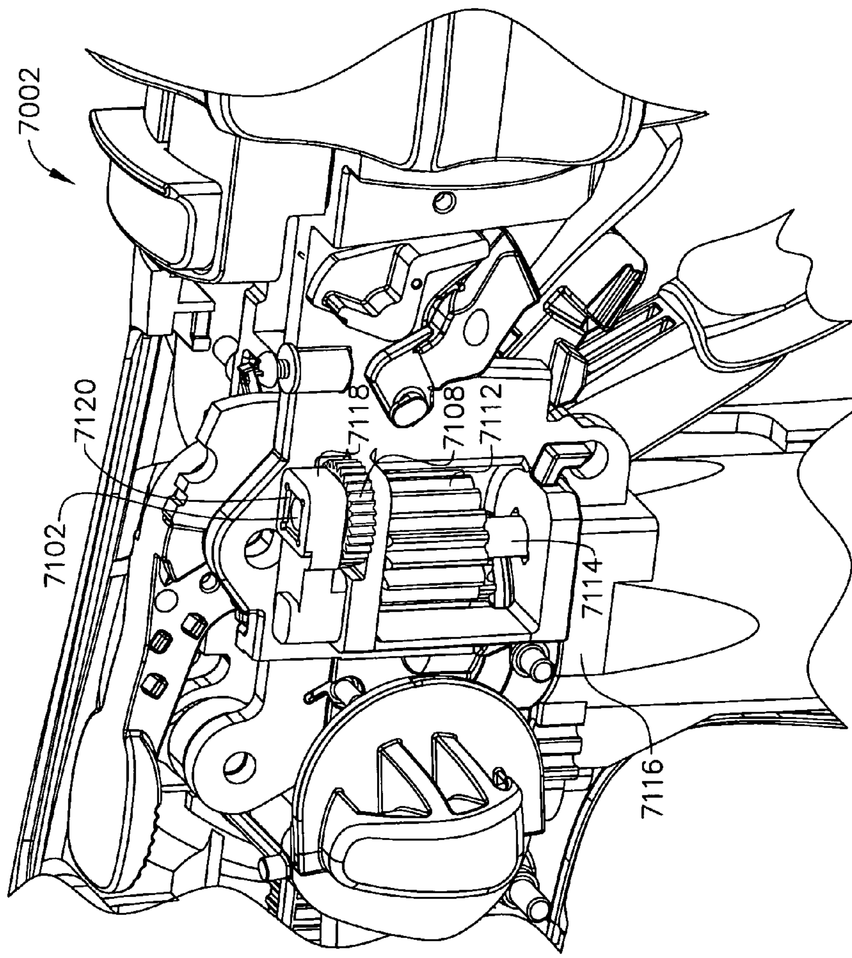



FIG. 189

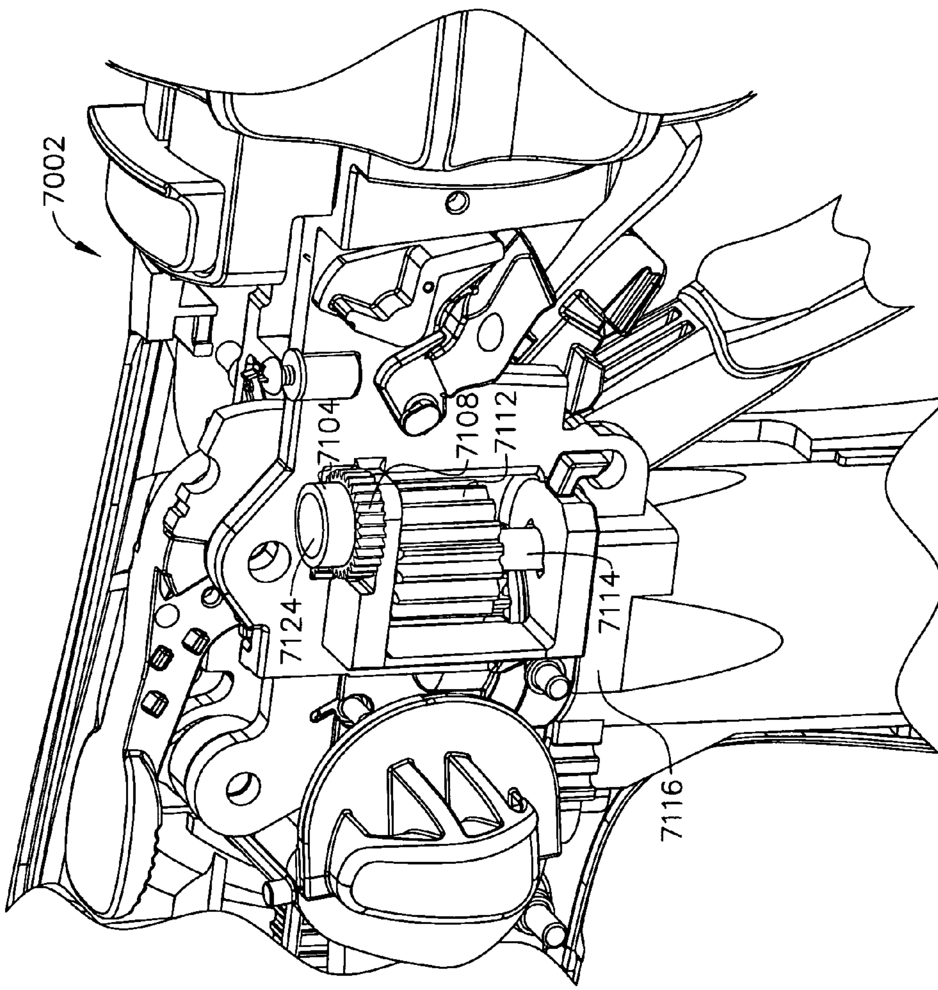



FIG. 190

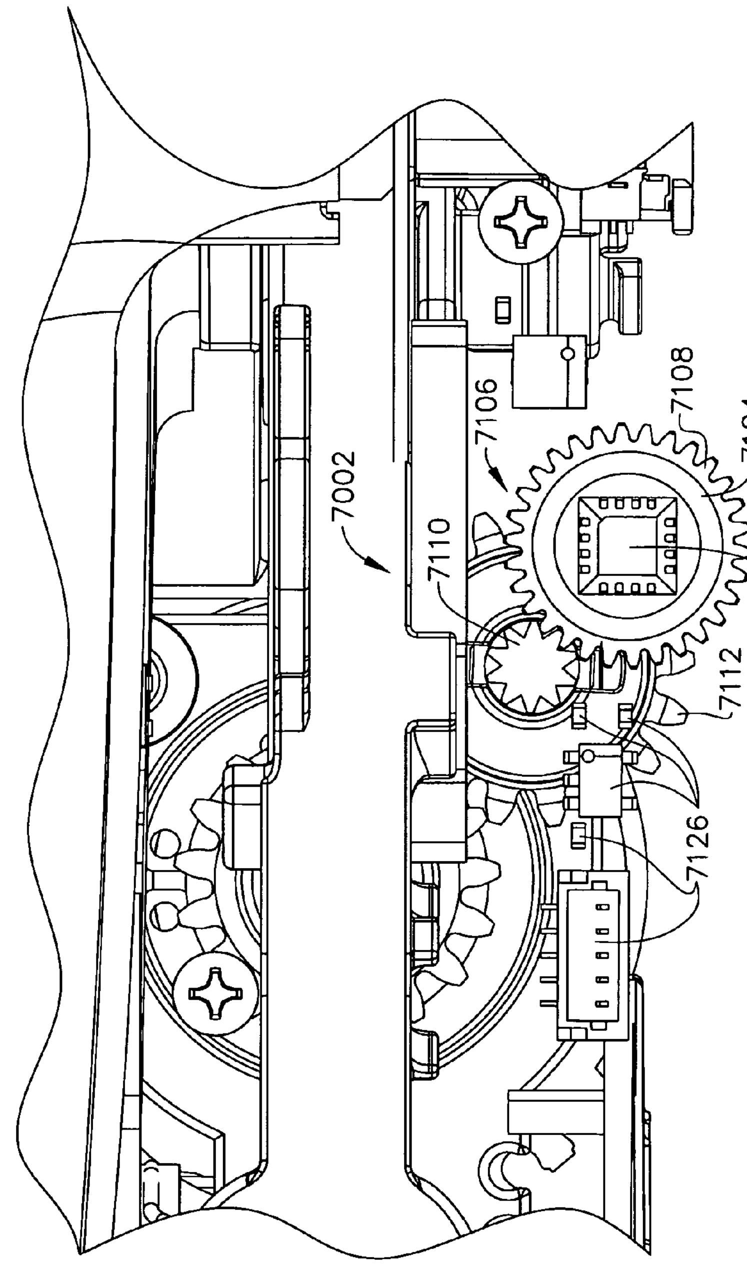



FIG. 191

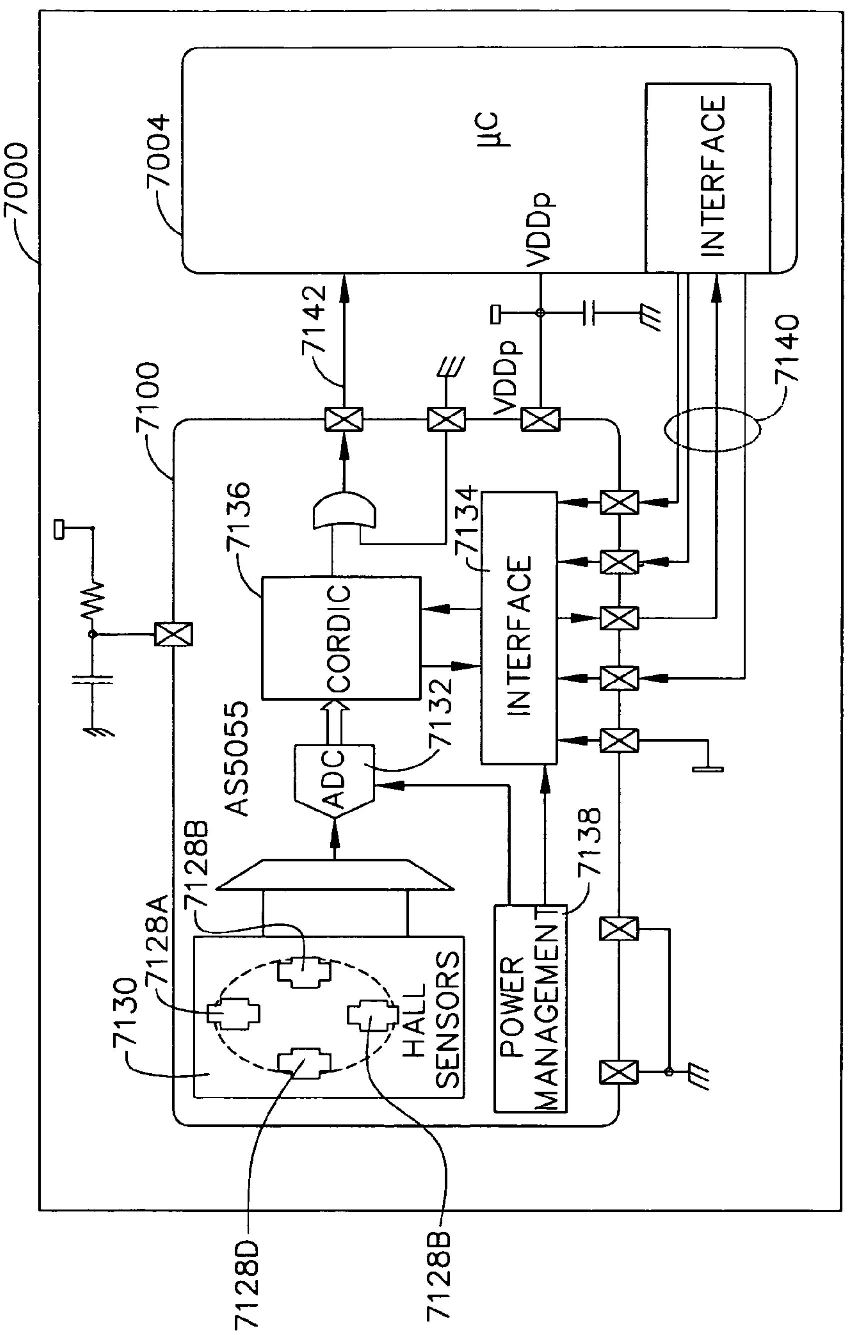

7000
7004
μC
INTERFACE
VDDp
7142
VDDp
7140
7100
7136
7134
CORDIC
INTERFACE
AS5055
ADC
7132
7128B
7128A
7130
HALL
SENSORS
POWER
MANAGEMENT
7138
7128D
7128B

FIG. 192

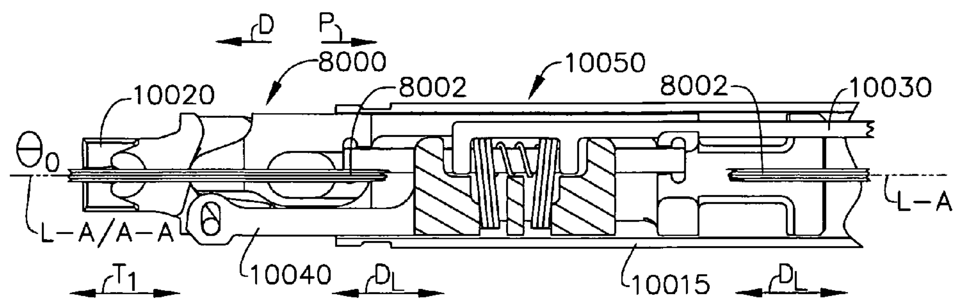



FIG. 193

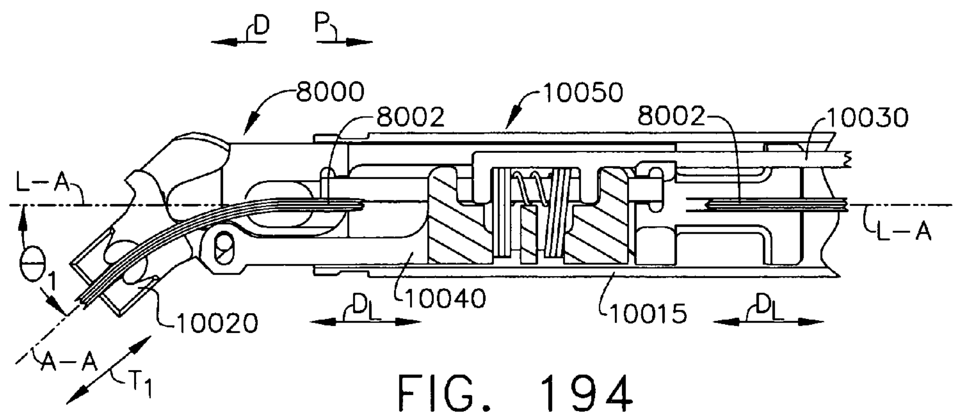



FIG. 194

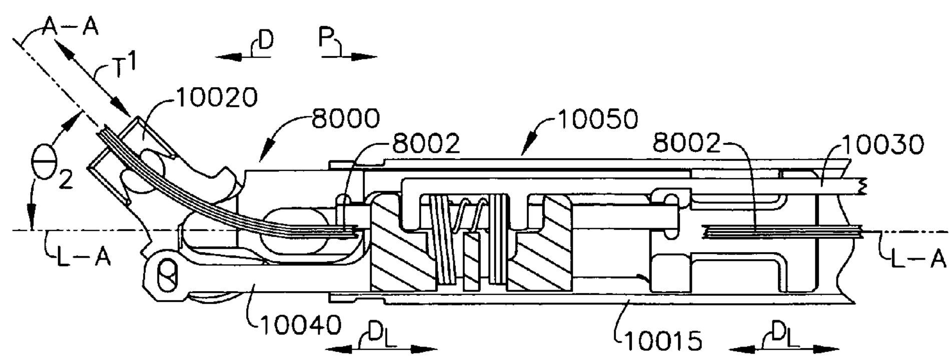



FIG. 195

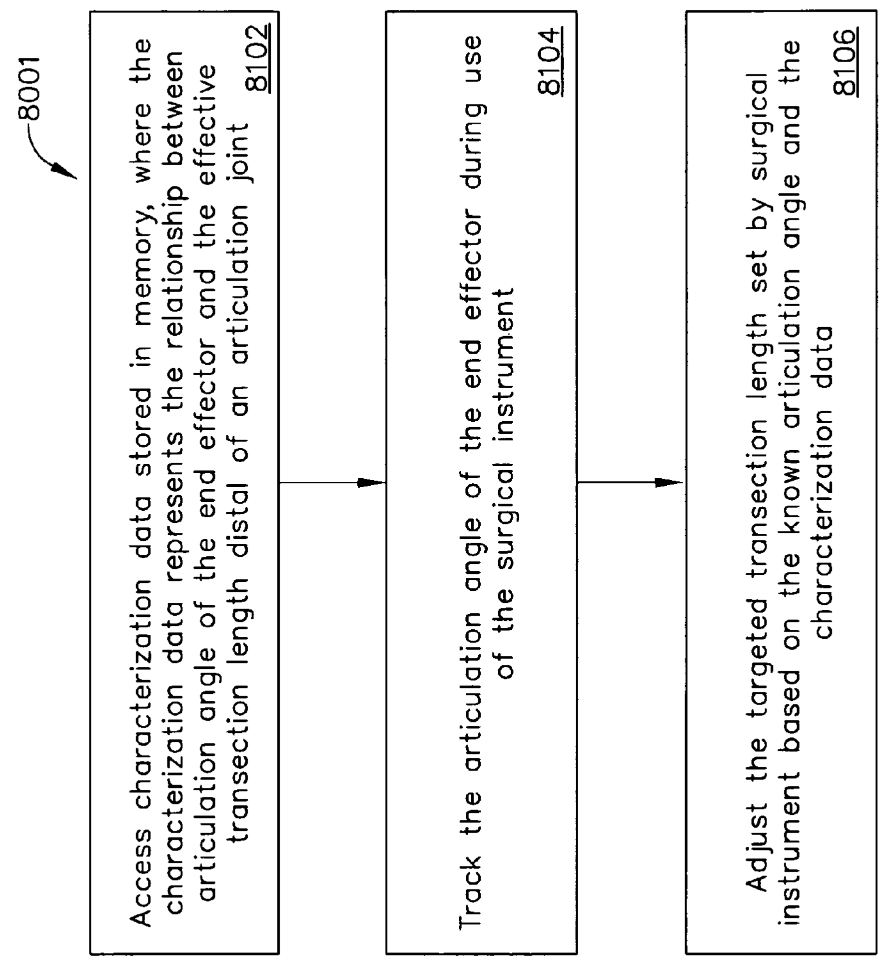

8001
Access characterization data stored in memory, where the characterization data represents the relationship between articulation angle of the end effector and the effective transection length distal of an articulation joint
8102
Track the articulation angle of the end effector during use of the surgical instrument
8104
Adjust the targeted transection length set by surgical instrument based on the known articulation angle and the characterization data
8106

FIG. 196

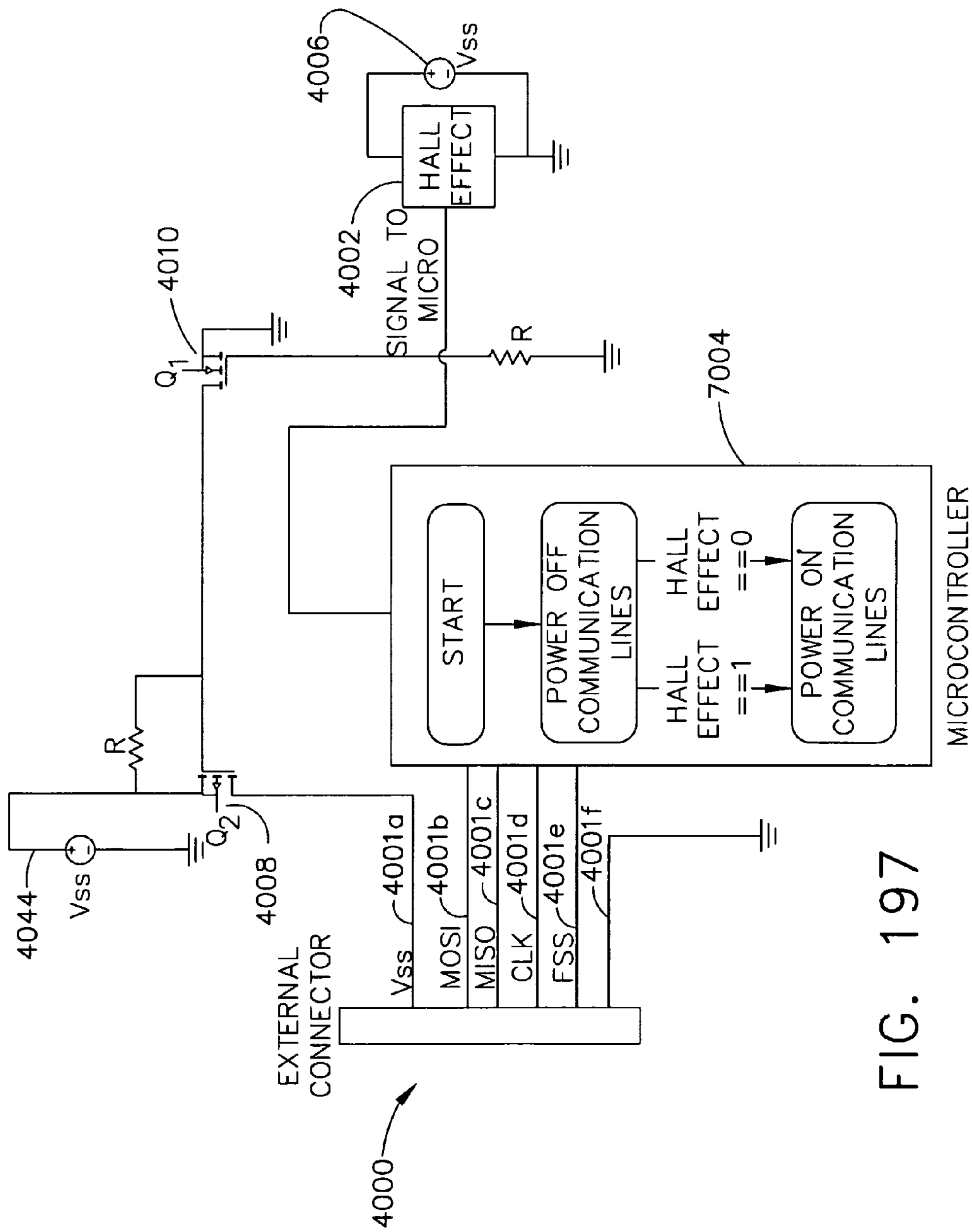

4006
Vss
HALL EFFECT
4002
SIGNAL TO MICRO
4010
$Q_1$
R
7004
START
POWER OFF COMMUNICATION LINES
HALL EFFECT ==1
HALL EFFECT ==0
POWER ON COMMUNICATION LINES
MICROCONTROLLER
R
$Q_2$
4008
4044
Vss
4001a
4001b
4001c
4001d
4001e
4001f
Vss
MOSI
MISO
CLK
FSS
EXTERNAL CONNECTOR
4000

FIG. 197

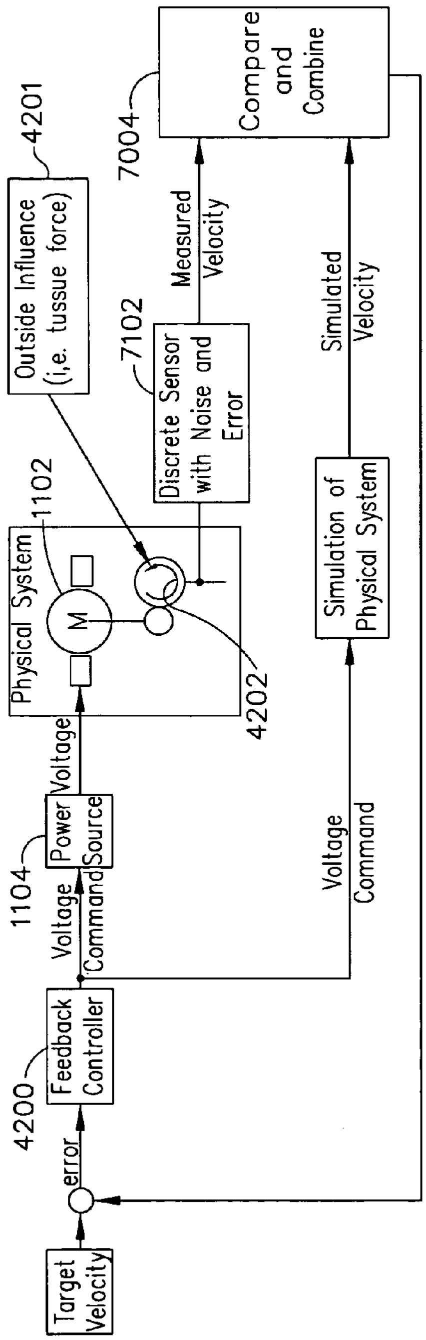



FIG. 198

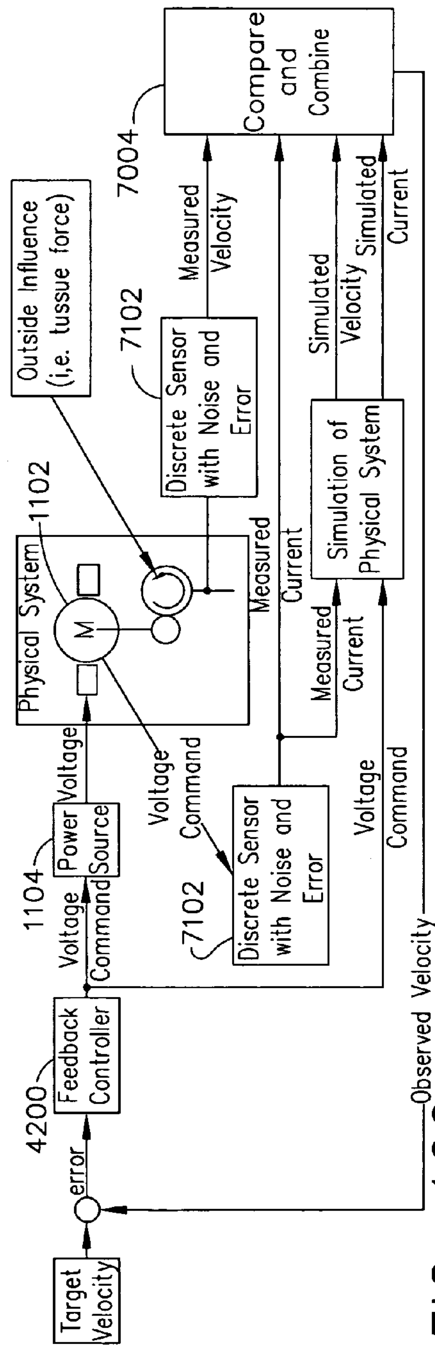



FIG. 199

# ARTICULATION CONTROL SYSTEM FOR ARTICULATABLE SURGICAL INSTRUMENTS

## BACKGROUND

The present invention relates to surgical instruments and, in various embodiments, to surgical cutting and stapling instruments and staple cartridges therefor that are designed to cut and staple tissue.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a perspective view of a surgical instrument comprising a handle, a shaft, and an articulatable end effector;

FIG. **2** is an elevational view of the surgical instrument of FIG. **1**;

FIG. **3** is a plan view of the surgical instrument of FIG. **1**;

FIG. **4** is a cross-sectional view of the end effector and the shaft of the surgical instrument of FIG. **1**;

FIG. **5** is a detail view of an articulation joint which rotatable connects the shaft and the end effector of FIG. **1** which illustrates the end effector in a neutral, or centered, position;

FIG. **6** is a cross-sectional view of an articulation control of the surgical instrument of FIG. **1** in a neutral, or centered, position;

FIG. **7** is an exploded view of the end effector, elongate shaft, and articulation joint of the surgical instrument of FIG. **1**;

FIG. **8** is a cross-sectional view of the end effector, elongate shaft, and articulation joint of the surgical instrument of FIG. **1**;

FIG. **9** is a perspective view of the end effector, elongate shaft, and articulation joint of the surgical instrument of FIG. **1**;

FIG. **10** depicts the end effector of the surgical instrument of FIG. **1** articulated about the articulation joint;

FIG. **11** is a cross-sectional view of the articulation control of FIG. **6** actuated to move the end effector as shown in FIG. **12**;

FIG. **12** is a perspective view of a surgical instrument comprising a handle, a shaft, and an articulatable end effector;

FIG. **13** is a side view of the surgical instrument of FIG. **12**;

FIG. **14** is a perspective view of a firing member and a pinion gear positioned within the handle of FIG. **12**;

FIG. **15** is a perspective view of the firing member and the pinion gear of FIG. **14** and a gear reducer assembly operably engaged with the pinion gear;

FIG. **16** is a perspective view of the handle of FIG. **12** with portions thereof removed to illustrate the firing member and the pinion gear of FIG. **14**, the gear reducer assembly of FIG. **15**, and an electric motor configured to drive the firing member distally and/or proximally depending on the direction in which the electric motor is turned;

FIG. **17** is a perspective view of a surgical instrument comprising a handle, a shaft, an end effector, and an articulation joint connecting the end effector to the shaft illustrated with portions of the handle removed for the purposes of illustration;

FIG. **18** is a cross-sectional view of the surgical instrument of FIG. **17**;



FIG. **19** is an exploded view of the surgical instrument of FIG. **17**;

FIG. **20** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrated with the end effector in an open configuration, the articulation joint in an unlocked configuration, and an articulation lock actuator of the surgical instrument handle illustrated in an unlocked configuration;

FIG. **21** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating the end effector in an articulated, open configuration, the articulation joint in an unlocked configuration, and an articulation driver engaged with a firing member of the surgical instrument of FIG. **17**, wherein the movement of the firing member can motivate the articulation driver and articulate the end effector;

FIG. **22** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating the end effector in a closed configuration, the articulation joint in an unlocked configuration, and an end effector closing drive being actuated to close the end effector and move the articulation lock actuator into a locked configuration;

FIG. **22**A is a cross-sectional detail view of the handle of the surgical instrument of FIG. **17** illustrated in the configuration described with regard to FIG. **22**;

FIG. **23** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating the end effector in a closed configuration and the articulation joint in a locked configuration, wherein the actuated closing drive prevents the articulation lock actuator from being moved into its unlocked configuration illustrated in FIGS. **20**-**22**;

FIG. **24**A is a plan view of the articulation joint of the surgical instrument of FIG. **17** illustrated in a locked configuration;

FIG. **24**B is a plan view of the articulation joint of the surgical instrument of FIG. **17** illustrated in an unlocked configuration;

FIG. **25** is a cross-sectional detail view of the handle of the surgical instrument of FIG. **17** illustrating the articulation driver disconnected from the firing member by closure drive;

FIG. **26** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating the firing member in an at least partially fired position and the articulation driver disconnected from the firing member by the closure drive;

FIG. **27** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating end effector in a closed configuration, the articulation joint and the articulation joint actuator in a locked configuration, and the firing member in a retracted position;

FIG. **28** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating the end effector in an open configuration, the end effector closing drive in a retracted position, and the articulation joint in a locked configuration;

FIG. **29** is a cross-sectional detail view of the surgical instrument of FIG. **17** illustrating the end effector in an open configuration and the articulation joint and the articulation joint actuator in an unlocked configuration wherein the articulation driver can be reconnected to the firing drive and utilized to articulate the end effector once again;

FIG. **30** is an exploded view of a shaft and an end effector of a surgical instrument including an alternative articulation lock arrangement;

FIG. **31** is a cross-sectional elevational view of the end effector and the shaft of the surgical instrument of FIG. **30** illustrating the end effector in an unlocked configuration;

FIG. **32** is a cross-sectional elevational view of the end effector and the shaft of the surgical instrument of FIG. **30** illustrating the end effector in a locked configuration;

FIG. **33** is an assembly view of one form of surgical system including a surgical instrument and a plurality of interchangeable shaft assemblies;

FIG. **34** is a perspective view of a surgical instrument handle coupled to an interchangeable shaft assembly;

FIG. **35** is an exploded perspective view of the surgical instrument handle of FIG. **34**;

FIG. **36** is a side elevational view of the handle of FIG. **35** with a portion of the handle housing removed;

FIG. **37** is an exploded perspective view of an interchangeable shaft assembly;

FIG. **38** is a side elevational assembly view of a portion of the handle and interchangeable shaft assembly of FIG. **34** illustrating the alignment of those components prior to being coupled together and with portions thereof omitted for clarity;

FIG. **39** is a perspective view of a portion of an interchangeable shaft assembly prior to attachment to a handle of a surgical instrument;

FIG. **40** is a side view of a portion of an interchangeable shaft assembly coupled to a handle with the lock yoke in a locked or engaged position with a portion of the frame attachment module of the handle;

FIG. **41** is another side view of the interchangeable shaft assembly and handle of FIG. **40** with the lock yoke in the disengaged or unlocked position;

FIG. **42** is a top view of a portion of an interchangeable shaft assembly and handle prior to being coupled together;

FIG. **43** is another top view of the interchangeable shaft assembly and handle of FIG. **42** coupled together;

FIG. **44** is a side elevational view of an interchangeable shaft assembly aligned with a surgical instrument handle prior to being coupled together;

FIG. **45** is a front perspective view of the interchangeable shaft assembly and surgical instrument handle of FIG. **44** with portions thereof removed for clarity;

FIG. **46** is a side view of a portion of an interchangeable shaft assembly aligned with a portion of a surgical instrument handle prior to being coupled together and with portions thereof omitted for clarity;

FIG. **47** is another side elevational view of the interchangeable shaft assembly and handle of FIG. **46** wherein the shaft assembly is in partial coupling engagement with the handle;

FIG. **48** is another side elevational view of the interchangeable shaft assembly and handle of FIGS. **46** and **47** after being coupled together;

FIG. **49** is another side elevational view of a portion of an interchangeable shaft assembly aligned with a portion of handle prior to commencing the coupling process;

FIG. **50** is a top view of a portion of another interchangeable shaft assembly and a portion of another surgical instrument frame arrangement;

FIG. **51** is another top view of the interchangeable shaft assembly and frame portion of FIG. **50** after being coupled together;

FIG. **52** is an exploded perspective view of the interchangeable shaft assembly and frame portion of FIG. **50**;

FIG. **53** is another exploded perspective view of the interchangeable shaft assembly and frame portion of FIG. **52** with the shaft attachment module of the shaft assembly in alignment with the frame attachment module of the frame portion prior to coupling;

FIG. **54** is a side elevational view of the interchangeable shaft assembly and frame portion of FIG. **52**;

FIG. **55** is a perspective view of the interchangeable shaft assembly and frame portion of FIGS. **53** and **54** after being coupled together;



FIG. **56** is a side elevational view of the interchangeable shaft assembly and frame portion of FIG. **55**;

FIG. **57** is another perspective view of the interchangeable shaft assembly and frame portion of FIGS. **55** and **56** with portions thereof omitted for clarity;

FIG. **58** is a top view of a portion of another interchangeable shaft assembly and frame portion of a surgical instrument prior to being coupled together;

FIG. **59** is another top view of the interchangeable shaft assembly and frame portion of FIG. **58** after being coupled together;

FIG. **60** is a perspective view of the interchangeable shaft assembly and frame of FIGS. **58** and **59** prior to being coupled together;

FIG. **61** is another perspective view of the interchangeable shaft assembly and frame portion of FIGS. **58-60** after being coupled together;

FIG. **62** is another perspective view of the interchangeable shaft assembly and frame portion of FIGS. **58-60** after being coupled together, with portions of the shaft assembly shown in cross-section;

FIG. **63** is an exploded perspective assembly view of another end effector shaft assembly and frame portion of a surgical instrument;

FIG. **64** is a top exploded assembly view of the end effector shaft assembly and frame portion of FIG. **63**;

FIG. **65** is another exploded perspective assembly view of the end effector shaft assembly and frame portion of FIGS. **63** and **64**;

FIG. **66** is a perspective view of the end effector shaft assembly and frame portion of FIGS. **63-65** after being coupled together;

FIG. **67** is a side elevational view of the end effector shaft assembly and frame portion of FIG. **66** with portions thereof omitted for clarity;

FIG. **68** is a top exploded assembly view of another end effector shaft assembly and frame portion of another surgical instrument;

FIG. **69** is a perspective exploded assembly view of the end effector shaft assembly and frame portion of FIG. **68**;

FIG. **70** is another perspective assembly view of the end effector shaft assembly and frame portion of FIGS. **68** and **69** with the end effector shaft assembly prior to being latched in coupled engagement with the frame portion;

FIG. **71** is a top view of the end effector shaft assembly and frame portion of FIG. **70**;

FIG. **72** is a top view of the end effector shaft assembly and frame portion of FIGS. **68-71** after being coupled together;

FIG. **73** is a side elevational view of the end effector shaft assembly and frame portion of FIG. **72**;

FIG. **74** is a perspective view of the end effector shaft assembly and frame portion of FIGS. **72** and **73**;

FIG. **75** is an exploded assembly view of an interchangeable shaft assembly and corresponding handle with some components thereof shown in cross-section;

FIG. **76** is a partial cross-sectional perspective view of portions of the end effector shaft assembly and the handle of FIG. **75**;

FIG. **77** is a partial perspective view of the end effector shaft assembly and handle of FIGS. **75** and **76** coupled together with various components omitted for clarity;

FIG. **78** is a side elevational view of the end effector shaft assembly and handle of FIG. **77**;

FIG. **79** is a side elevational view of the end effector shaft assembly and handle of FIGS. **75-78** coupled together with the closure drive in an unactuated position and with some components shown in cross-section;

FIG. **80** is another side elevational view of the end effector shaft assembly and handle of FIG. **79** with the closure drive in a fully actuated position;

FIG. **81** is an exploded assembly view of an interchangeable shaft assembly and corresponding handle with some components thereof omitted for clarity and wherein the closure drive system is in a locked orientation;

FIG. **82** is a side view of the end effector shaft assembly and handle of FIG. **81** coupled together with various components omitted for clarity and wherein the closure drive system is in an unlocked and unactuated position;

FIG. **83** is a side view of the end effector shaft assembly and handle of FIG. **82** with various components shown in cross-section for clarity;

FIG. **84** is a side view of the end effector shaft assembly and handle of FIGS. **81-83** coupled together with various components omitted for clarity and wherein the closure drive system is in an actuated position;

FIG. **85** is a side view of the end effector shaft assembly and handle of FIG. **84** with various components shown in cross-section for clarity;

FIG. **86** is an exploded perspective assembly view of a portion of an interchangeable shaft assembly and a portion of a handle of a surgical instrument;

FIG. **87** is a side elevational view of the portions of the interchangeable shaft assembly and handle of FIG. **86**;

FIG. **88** is another exploded perspective assembly view of portions of the interchangeable shaft assembly and handle of FIGS. **86** and **87** with portions of the interchangeable shaft assembly shown in cross-section for clarity;

FIG. **89** is another side elevational view of portions of the interchangeable shaft assembly and handle of FIGS. **86-88** with portions thereof shown in cross-section for clarity;

FIG. **90** is a side elevational view of the portions of the interchangeable shaft assembly and handle of FIGS. **86-89** after the interchangeable shaft assembly has been operably coupled to the handle and with portions of thereof shown in cross-section for clarity;

FIG. **91** is another side elevational view of portions of the interchangeable shaft assembly and handle coupled thereto with the closure drive system in a fully-actuated position;

FIG. **92** is an exploded perspective assembly view of a portion of another interchangeable shaft assembly and a portion of a handle of another surgical instrument;

FIG. **93** is a side elevational view of portions of the interchangeable shaft assembly and handle of FIG. **92** in alignment prior to being coupled together;

FIG. **94** is another exploded perspective view of the interchangeable shaft assembly and handle of FIGS. **92** and **93** with some portions thereof shown in cross-section;

FIG. **95** is another perspective view of the interchangeable shaft assembly and handle of FIGS. **92-94** coupled together in operable engagement;

FIG. **96** is a side elevational view of the interchangeable shaft assembly and handle of FIG. **95**;

FIG. **97** is another side elevational view of the interchangeable shaft assembly and handle of FIG. **96** with some components thereof shown in cross-section;

FIG. **98** is another side elevational view of the interchangeable shaft assembly and handle of FIGS. **92-96** with the closure trigger in a fully actuated position;

FIG. **99** is a perspective view of a portion of another interchangeable shaft assembly that includes a shaft locking assembly arrangement;

FIG. **100** is a perspective view of the shaft locking assembly arrangement depicted in FIG. **99** in a locked position with the intermediate firing shaft portion of the firing member of an interchangeable shaft assembly;

FIG. **101** is another perspective view of the shaft locking assembly and intermediate firing member portion with the shaft locking assembly in an unlocked position;

FIG. **102** is a schematic illustrating, one, a clutch assembly for operably connecting an articulation drive to a firing drive of a surgical instrument and, two, an articulation lock configured to releasably hold the articulation drive, and an end effector of the surgical instrument, in position, wherein FIG. **102** illustrates the clutch assembly in an engaged position and the articulation lock in a locked condition;

FIG. **103** is a schematic illustrating the clutch assembly of FIG. **102** in its engaged position and the articulation lock of FIG. **102** in a first unlocked condition which permits the articulation of the end effector of FIG. **102** in a first direction;

FIG. **104** is a schematic illustrating the clutch assembly of FIG. **102** in its engaged position and the articulation lock of FIG. **102** in a second unlocked condition which permits the articulation of the end effector of FIG. **102** in a second direction;

FIG. **104**A is an exploded view of the clutch assembly and the articulation lock of FIG. **102**;

FIG. **105** is a partial perspective view of a shaft assembly including the clutch assembly of FIG. **102** in its engaged position with portions of the shaft assembly removed for the purposes of illustration;

FIG. **106** is a partial top plan view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** in its engaged position;

FIG. **107** is a partial bottom plan view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** in its engaged position;

FIG. **108** is a partial perspective view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** in its engaged position with additional portions removed for the purposes of illustration;

FIG. **109** is a partial perspective view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** in a disengaged position with additional portions removed for the purposes of illustration;

FIG. **110** is a partial perspective view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** moved into a disengaged position by a closure drive of the shaft assembly;

FIG. **111** is a partial plan view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** in its engaged position with additional portions removed for the purposes of illustration;

FIG. **112** is a partial plan view of the shaft assembly of FIG. **105** illustrating the clutch assembly of FIG. **102** in a disengaged position with additional portions removed for the purposes of illustration;

FIG. **113** is a plan view of an alternative embodiment of an articulation lock illustrated in a locked condition;

FIG. **114** is an exploded view of the articulation lock of FIG. **113**;

FIG. **115** is a cross-sectional view of another alternative embodiment of an articulation lock illustrated in a locked condition;

FIG. **116** is an exploded view of the articulation lock of FIG. **114**;

FIG. **117** is a perspective view of another alternative embodiment of an articulation lock illustrated in a locked condition;

FIG. **118** is an exploded view of the articulation lock of FIG. **117**;

FIG. **119** is an elevational view of the articulation lock of FIG. **117** illustrating the articulation lock illustrated in a locked condition;

FIG. **120** is an elevational view of the articulation lock of FIG. **117** illustrating the articulation lock in a first unlocked condition to articulate an end effector in a first direction;

FIG. **121** is an elevational view of the articulation lock of FIG. **117** illustrating the articulation lock in a second unlocked condition to articulate an end effector in a second direction;

FIG. **122** is another exploded view of the articulation lock of FIG. **117**;

FIG. **123** is a perspective view of a first lock cam of the articulation lock of FIG. **117**;

FIG. **124** is a perspective view of a second lock cam of the articulation lock of FIG. **117**;

FIG. **125** is a perspective view of another alternative embodiment of an articulation lock illustrated in a locked condition;

FIG. **126** is an exploded view of the articulation lock of FIG. **125**;

FIG. **127** is a cross-sectional elevational view of the articulation lock of FIG. **125** illustrating the articulation lock in a first unlocked condition for articulating an end effector in a first direction;

FIG. **128** is a cross-sectional elevational view of the articulation lock of FIG. **125** illustrating the articulation lock in a locked condition;

FIG. **129** is a cross-sectional elevational view of the articulation lock of FIG. **125** illustrating the articulation lock in a second unlocked condition for articulating an end effector in a second direction;

FIG. **130** is a cross-sectional elevational view of the articulation lock of FIG. **125** illustrating the articulation lock in a locked condition;

FIG. **131** is a perspective view of a shaft assembly;

FIG. **132** is an exploded view of the shaft assembly of FIG. **131** illustrating an alternative embodiment of a clutch assembly for operably connecting an articulation drive with a firing drive of the shaft assembly;

FIG. **133** is another exploded view of the shaft assembly of FIG. **131**;

FIG. **134** is a partial exploded view of the shaft assembly of FIG. **131** illustrated with portions removed for the purposes of illustration;

FIG. **135** is an end view of the shaft assembly of FIG. **131** illustrated with portions removed for the purposes of illustration;

FIG. **136** is another end view of the shaft assembly of FIG. **131** illustrated with portions removed for the purposes of illustration;

FIG. **137** is a partial cross-sectional elevational view of the shaft assembly of FIG. **131**;

FIG. **138** is a partial cross-sectional perspective view of the shaft assembly of FIG. **131**;

FIG. **139** is another partial cross-sectional view of the shaft assembly of FIG. **131**;

FIG. **140** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, a clutch actuator is illustrated while a clutch sleeve, a switch drum, a proximal articulation driver, and a closure tube are not illustrated;

FIG. **141** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator and the clutch sleeve are illustrated while the switch drum, the proximal articulation driver, and the closure tube are not illustrated;

FIG. **142** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in a disengaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator and the clutch sleeve are illustrated while the switch drum, the proximal articulation driver, and the closure tube are not illustrated;

FIG. **143** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in a disengaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator, the clutch sleeve, and the closure tube are illustrated while the switch drum and the proximal articulation driver are not illustrated;

FIG. **144** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in a disengaged position; the clutch actuator, the clutch sleeve, the closure tube, the switch drum, and the proximal articulation driver are illustrated;

FIG. **145** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator, the clutch sleeve, and the proximal articulation driver are illustrated while the switch drum and the closure tube are not illustrated;

FIG. **146** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator, the clutch sleeve, the proximal articulation driver, and closure tube are illustrated while the switch drum is not illustrated; moreover, the articulation drive system of the shaft assembly is illustrated in a centered, or unarticulated, condition;

FIG. **147** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator, the clutch sleeve, and the proximal articulation driver are illustrated while the switch drum and the closure tube are not illustrated; moreover, the articulation drive system of the shaft assembly is illustrated in a condition in which an end effector of the shaft assembly would be articulated to the left of a longitudinal axis of the shaft assembly;

FIG. **148** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator, the clutch sleeve, and the proximal articulation driver are illustrated while the switch drum and the closure tube are not illustrated; moreover, the articulation drive system of the shaft assembly is illustrated in a condition in which the end effector of the shaft assembly would be articulated to the right of the longitudinal axis of the shaft assembly;

FIG. **149** is a perspective view of the shaft assembly of FIG. **131** illustrating the clutch assembly in an engaged position and illustrated with portions removed for the purposes of clarity; specifically, the clutch actuator, the clutch sleeve, the closure tube, and the proximal articulation driver are illustrated while the switch drum is not illustrated;

FIG. **150** is a perspective view of a surgical instrument in accordance with certain embodiments described herein;

FIG. **151** is a schematic block diagram of a control system of a surgical instrument in accordance with certain embodiments described herein;

FIG. **152** is a perspective view of an interface of a surgical instrument in accordance with certain embodiments described herein;

FIG. **153** is a top view of the interface of FIG. **152**;

FIG. **154** is a cross-sectional view of the interface of FIG. **152** in an inactive or neutral configuration in accordance with certain embodiments described herein;

FIG. **155** is a cross-sectional view of the interface of FIG. **152** activated to articulate an end effector in accordance with certain embodiments described herein;

FIG. **156** is a cross-sectional view of the interface of FIG. **152** activated to return an end effector to an articulation home state position in accordance with certain embodiments described herein;

FIG. **157** is a cross-sectional view of an interface similar to the interface of FIG. **152** in an inactive or neutral configuration in accordance with certain embodiments described herein;

FIG. **158** is a cross-sectional view of the interface of FIG. **152** activated to articulate an end effector in accordance with certain embodiments described herein;

FIG. **159** is a cross-sectional view of the interface of FIG. **152** activated to return the end effector to an articulation home state position in accordance with certain embodiments described herein;

FIG. **160** is a schematic block diagram outlining a response of a controller of the surgical instrument of FIG. **150** to a reset input signal in accordance with certain embodiments described herein;

FIG. **161** is a schematic block diagram outlining a response of a controller of the surgical instrument of FIG. **150** to a home state input signal in accordance with certain embodiments described herein;

FIG. **162** is a schematic block diagram outlining a response of a controller of the surgical instrument of FIG. **150** to a home state input signal in accordance with certain embodiments described herein;

FIG. **163** is a schematic block diagram outlining a response of a controller of the surgical instrument of FIG. **150** to a firing home state input signal in accordance with certain embodiments described herein;

FIG. **164** is side elevational view of a surgical instrument including a handle separated from a shaft according to various embodiments described herein;

FIG. **165** is a side elevational view of a handle portion including an interlock switch and a shaft portion including a locking member according to various embodiments described herein;

FIG. **166** is a partial cross-sectional view of the surgical instrument in FIG. **150** illustrating a locking member in the locked configuration and an open switch according to various embodiments described herein;

FIG. **167** is a partial cross-sectional view of the surgical instrument in FIG. **150** illustrating a locking member in the unlocked configuration and a s closed switch depressed by the locking member according to various embodiments described herein;

FIG. **167**A is a partial cross-sectional view of the surgical instrument in FIG. **150** illustrating an advanced firing drive according to various embodiments described herein;

FIG. **167**B is a partial cross-sectional view of the surgical instrument in FIG. **150** illustrating a firing drive in a retracted or default position according to various embodiments described herein;

FIG. **168** is a schematic block diagram outlining a response of a controller of the surgical instrument of FIG. **150** to an input signal in accordance with certain embodiments described herein;

FIG. **169** is a schematic block diagram outlining a response of a controller of the surgical instrument of FIG. **150** to an input signal in accordance with certain embodiments described herein;

FIG. **170** is a bottom view of an electric motor and a resonator according to various embodiments of the present disclosure;

FIG. **171** is a perspective view of the resonator of FIG. **170**;

FIG. **172** is a bottom view of the resonator of FIG. **170**;

FIG. **173** is a partial perspective view of a handle of a surgical instrument depicting the electric motor of FIG. **170** and a resonator positioned within the handle according to various embodiments of the present disclosure;

FIG. **174** is a bottom view of the electric motor and the resonator of FIG. **173**;

FIG. **175** is a perspective view of the resonator of FIG. **173**;

FIG. **176** is a bottom view of the resonator of FIG. **173**;

FIG. **177** is a partial perspective view of the handle of FIG. **173** depicting the electric motor of FIG. **170** and a resonator positioned within the handle according to various embodiments of the present disclosure;

FIG. **178** is a bottom view of the electric motor and the resonator of FIG. **177**;

FIG. **179** is a first perspective view of the resonator of FIG. **177**;

FIG. **180** is a second perspective view of the resonator of FIG. **177**;

FIG. **181** is a perspective view of the handle of FIG. **173**, depicting the electric motor of FIG. **170**, a resonator, and a retaining ring positioned within the handle according to various embodiments of the present disclosure;

FIG. **182** is a flowchart of the operation of a surgical instrument during a surgical procedure according to various embodiments of the present disclosure;

FIG. **183** is an exploded perspective view of the surgical instrument handle of FIG. **34** showing a portion of a sensor arrangement for an absolute positioning system, according to one embodiment;

FIG. **184** is a side elevational view of the handle of FIGS. **34** and **183** with a portion of the handle housing removed showing a portion of a sensor arrangement for an absolute positioning system, according to one embodiment;

FIG. **185** is a schematic diagram of an absolute positioning system comprising a microcontroller controlled motor drive circuit arrangement comprising a sensor arrangement, according to one embodiment;

FIG. **186** is a detail perspective view of a sensor arrangement for an absolute positioning system, according to one embodiment;

FIG. **187** is an exploded perspective view of the sensor arrangement for an absolute positioning system showing a control circuit board assembly and the relative alignment of the elements of the sensor arrangement, according to one embodiment;

FIG. **188** is a side perspective view of the sensor arrangement for an absolute positioning system showing a control circuit board assembly, according to one embodiment;

FIG. **189** is a side perspective view of the sensor arrangement for an absolute positioning system with the control circuit board assembly removed to show a sensor element holder assembly, according to one embodiment;

FIG. **190** is a side perspective view of the sensor arrangement for an absolute positioning system with the control circuit board and the sensor element holder assemblies removed to show the sensor element, according to one embodiment;

FIG. **191** is a top view of the sensor arrangement for an absolute positioning system shown in with the control circuit board removed but the electronic components still visible to show the relative position between the position sensor and the circuit components, according to one embodiment;

FIG. **192** is a schematic diagram of one embodiment of a position sensor for an absolute positioning system comprising a magnetic rotary absolute positioning system, according to one embodiment;

FIG. **193** illustrates an articulation joint in a straight position, i.e., at a zero angle relative to the longitudinal direction, according to one embodiment;

FIG. **194** illustrates the articulation joint of FIG. **193** articulated in one direction at a first angle defined between a longitudinal axis L-A and an articulation axis A-A, according to one embodiment;

FIG. **195** illustrates the articulation joint of FIG. **193** articulated in another at a second angle defined between the longitudinal axis L-A and the articulation axis A'-A, according to one embodiment;

FIG. **196** illustrates one embodiment of a logic diagram for a method of compensating for the effect of splay in flexible knife bands on transection length;

FIG. **197** is a schematic of a system for powering down an electrical connector of a surgical instrument handle when a shaft assembly is not coupled thereto;

FIG. **198** is a schematic illustrating a system for controlling the speed of a motor and/or the speed of a driveable member of a surgical instrument disclosed herein; and

FIG. **199** is a schematic illustrating another system for controlling the speed of a motor and/or the speed of a driveable member of a surgical instrument disclosed herein.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate certain embodiments of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

## DETAILED DESCRIPTION

Applicant of the present application owns the following patent applications that were filed on Mar. 1, 2013 and which are each herein incorporated by reference in their respective entireties:

U.S. patent application Ser. No. 13/782,295, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH CONDUCTIVE PATHWAYS FOR SIGNAL COMMUNICATION, now U.S. Patent Application Publication No. 2014/024571;

U.S. patent application Ser. No. 13/782,323, entitled ROTARY POWERED ARTICULATION JOINTS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0246472;

U.S. patent application Ser. No. 13/782,338, entitled THUMBWHEEL SWITCH ARRANGEMENTS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0249557;

U.S. patent application Ser. No. 13/782,499, entitled ELECTROMECHANICAL SURGICAL DEVICE WITH SIGNAL RELAY ARRANGEMENT, now U.S. Patent Application Publication No. 2014/0246474;

U.S. patent application Ser. No. 13/782,460, entitled MULTIPLE PROCESSOR MOTOR CONTROL FOR MODULAR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0246478;

U.S. patent application Ser. No. 13/782,358, entitled JOYSTICK SWITCH ASSEMBLIES FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0246477;

U.S. patent application Ser. No. 13/782,481, entitled SENSOR STRAIGHTENED END EFFECTOR DURING REMOVAL THROUGH TROCAR, now U.S. Patent Application Publication No. 2014/0246479;

U.S. patent application Ser. No. 13/782,518, entitled CONTROL METHODS FOR SURGICAL INSTRUMENTS WITH REMOVABLE IMPLEMENT PORTIONS, now U.S. Patent Application Publication No. 2014/0246475;

U.S. patent application Ser. No. 13/782,375, entitled ROTARY POWERED SURGICAL INSTRUMENTS WITH MULTIPLE DEGREES OF FREEDOM, now U.S. Patent Application Publication No. 2014/0246473; and

U.S. patent application Ser. No. 13/782,536, entitled SURGICAL INSTRUMENT SOFT STOP, now U.S. Patent Application Publication No. 2014/0246476 are hereby incorporated by reference in their entireties.

Applicant of the present application also owns the following patent applications that were filed on Mar. 14, 2013 and which are each herein incorporated by reference in their respective entireties:

U.S. patent application Ser. No. 13/803,193, entitled CONTROL ARRANGEMENTS FOR A DRIVE MEMBER OF A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0263537;

U.S. patent application Ser. No. 13/803,053, entitled INTERCHANGEABLE SHAFT ASSEMBLIES FOR USE WITH A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0263564;

U.S. patent application Ser. No. 13/803,086, entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING AN ARTICULATION LOCK, now U.S. Patent Application Publication No. 2014/0263541;

U.S. patent application Ser. No. 13/803,210, entitled SENSOR ARRANGEMENTS FOR ABSOLUTE POSITIONING SYSTEM FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263538;

U.S. patent application Ser. No. 13/803,148, entitled MULTI-FUNCTION MOTOR FOR A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0263554;

U.S. patent application Ser. No. 13/803,066, entitled DRIVE SYSTEM LOCKOUT ARRANGEMENTS FOR MODULAR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263565;

U.S. patent application Ser. No. 13/803,130, entitled DRIVE TRAIN CONTROL ARRANGEMENTS FOR MODULAR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263543;

U.S. patent application Ser. No. 13/803,159, entitled METHOD AND SYSTEM FOR OPERATING A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0277017; and

U.S. patent application Ser. No. 13/803,097, entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING A FIRING DRIVE, now U.S. Patent Application Publication No. 2014/0263542.

Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the various embodiments of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

Reference throughout the specification to "various embodiments," "some embodiments," "one embodiment," or "an embodiment", or the like, means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in various embodiments," "in some embodiments," "in one embodiment", or "in an embodiment", or the like, in places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Thus, the particular features, structures, or characteristics illustrated or described in connection with one embodiment may be combined, in whole or in part, with the features structures, or characteristics of one or more other embodiments without limitation. Such modifications and variations are intended to be included within the scope of the present invention.

The terms "proximal" and "distal" are used herein with reference to a clinician manipulating the handle portion of the surgical instrument. The term "proximal" referring to the portion closest to the clinician and the term "distal" referring to the portion located away from the clinician. It will be further appreciated that, for convenience and clarity, spatial terms such as "vertical", "horizontal", "up", and "down" may be used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and/or absolute.

Various exemplary devices and methods are provided for performing laparoscopic and minimally invasive surgical procedures. However, the person of ordinary skill in the art will readily appreciate that the various methods and devices disclosed herein can be used in numerous surgical procedures and applications including, for example, in connection with open surgical procedures. As the present Detailed Description proceeds, those of ordinary skill in the art will further appreciate that the various instruments disclosed herein can be inserted into a body in any way, such as through a natural orifice, through an incision or puncture hole formed in tissue, etc. The working portions or end effector portions of the instruments can be inserted directly into a patient's body or can be inserted through an access device that has a working channel through which the end effector and elongated shaft of a surgical instrument can be advanced.

FIGS. **1-3** illustrate an exemplary surgical instrument **100** which can include a handle **103**, a shaft **104** and an articulating end effector **102** pivotally connected to the shaft **104** at articulation joint **110**. An articulation control **112** is provided to effect rotation of the end effector **102** about articulation joint **110**. The end effector **102** is shown configured to act as an endocutter for clamping, severing and stapling tissue, however, it will be appreciated that various embodiments may include end effectors configured to act as other surgical devices including, for example, graspers, cutters, staplers, clip appliers, access devices, drug/gene therapy delivery devices, ultrasound, RF, and/or laser energy devices, etc. The handle **103** of the instrument **100** may include closure trigger **114** and firing trigger **116** for actuating the end effector **102**.

It will be appreciated that instruments having end effectors directed to different surgical tasks may have different numbers or types of triggers or other suitable controls for operating an end effector. The end effector **102** is connected to the handle **103** by shaft **104**. A clinician may articulate the end effector **102** relative to the shaft **104** by utilizing the articulation control **112**, as described in greater detail further below.

It should be appreciated that spatial terms such as vertical, horizontal, right, left etc., are given herein with reference to the figures assuming that the longitudinal axis of the surgical instrument **100** is co-axial to the central axis of the shaft **104**, with the triggers **114**, **116** extending downwardly at an acute angle from the bottom of the handle **103**. In actual practice, however, the surgical instrument **100** may be oriented at various angles and as such these spatial terms are used relative to the surgical instrument **100** itself. Further, proximal is used to denote a perspective of a clinician who is behind the handle **103** who places the end effector **102** distal, or away from him or herself. As used herein, the phrase, "substantially transverse to the longitudinal axis" where the "longitudinal axis" is the axis of the shaft, refers to a direction that is nearly perpendicular to the longitudinal axis. It will be appreciated, however, that directions that deviate some from perpendicular to the longitudinal axis are also substantially transverse to the longitudinal axis.

Various embodiments disclosed herein are directed to instruments having an articulation joint driven by bending cables or bands. FIGS. **4** and **5** show a cross-sectional top view of the elongate shaft **104** and the end effector **102** including a band **205** that is mechanically coupled to a boss **206** extending from the end effector **102**. The band **205** may include band portions **202** and **204** extending proximally from the boss **206** along the elongate shaft **104** and through the articulation control **112**. The band **205** and band portions **202**, **204** can have a fixed length. The band **205** may be mechanically coupled to the boss **206** as shown using any suitable fastening method including, for example, glue, welding, etc. In various embodiments, each band portion **202**, **204** may be provided as a separate band, with each separate band having one end mechanically coupled to the boss **206** and another end extending through the shaft **104** and articulation controller **112**. The separate bands may be mechanically coupled to the boss **206** as described above.

Further to the above, band portions **202**, **204** may extend from the boss **206**, through the articulation joint **110** and along the shaft **104** to the articulation control **112**, shown in FIG. **6**. The articulation control **112** can include an articulation slide **208**, a frame **212** and an enclosure **218**. Band portions **202**, **204** may pass through the articulation slide **208** by way of slot **210** or other aperture, although it will be appreciated that the band portions **202**, **204** may be coupled to the slide **208** by any suitable means. The articulation slide **208** may be one piece, as shown in FIG. **6**, or may include two pieces with an interface between the two pieces defining the slot **210**. In one non-limiting embodiment, the articulation slide **208** may include multiple slots, for example, with each slot configured to receive one of the band portions **202**, **204**. Enclosure **218** may cover the various components of the articulation control **112** to prevent debris from entering the articulation control **112**.

Referring again to FIG. **6**, the band portions **202**, **204** may be anchored to the frame **212** at connection points **214**, **216**, respectively, which are proximally located from the slot **210**. It will be appreciated that band portions **202**, **204** may be anchored anywhere in the instrument **10** located proximally from the slot **210**, including the handle **103**. The non-limiting embodiment of FIG. **6** shows that the band portions **202**, **204** can comprise a bent configuration between the connection points **214**, **216** and the slot **210** located near the longitudinal axis of the shaft **104**. Other embodiments are envisioned in which the band portions **202**, **204** are straight.

FIGS. **7-9** show views of the end effector **102** and elongate shaft **104** of the instrument **100** including the articulation joint **110** shown in FIG. **5**. FIG. **7** shows an exploded view of the end effector **102** and elongate shaft **104** including various internal components. In at least one embodiment, an end effector frame **150** and shaft frame **154** are configured to be joined at articulation joint **110**. Boss **206** may be integral to the end effector frame **150** with band **205** interfacing the boss **206** as shown. The shaft frame **154** may include a distally directed tang **302** defining an aperture **304**. The aperture **304** may be positioned to interface an articulation pin (not shown) included in end effector frame **150** allowing the end effector frame **150** to pivot relative to the shaft frame **154**, and accordingly, the end effector **102** to pivot relative to the shaft **104**. When assembled, the various components may pivot about articulation joint **110** at an articulation axis **306** shown in FIGS. **9** and **10**.

FIG. **7** also shows an anvil **120**. In this non-limiting embodiment, the anvil **120** is coupled to an elongate channel **198**. For example, apertures **199** can be defined in the elongate channel **198** which can receive pins **152** extending from the anvil **120** and allow the anvil **120** to pivot from an open position to a closed position relative to the elongate channel **198** and staple cartridge **118**. In addition, FIG. **7** shows a firing bar **172**, configured to longitudinally translate through the shaft frame **154**, through the flexible closure and pivoting frame articulation joint **110**, and through a firing slot **176** in the distal frame **150** into the end effector **102**. The firing bar **172** may be constructed from one solid section, or in various embodiments, may include a laminate material comprising, for example, a stack of steel plates. It will be appreciated that a firing bar **172** made from a laminate material may lower the force required to articulate the end effector **102**. In various embodiments, a spring clip **158** can be mounted in the end effector frame **150** to bias the firing bar **172** downwardly. Distal and proximal square apertures **164**, **168** formed on top of the end effector frame **150** may define a clip bar **170** therebetween that receives a top arm **162** of a clip spring **158** whose lower, distally extended arm **160** asserts a downward force on a raised portion **174** of the firing bar **172**, as discussed below.

A distally projecting end of the firing bar **172** can be attached to an E-beam **178** that can, among other things, assist in spacing the anvil **120** from a staple cartridge **118** positioned in the elongate channel **198** when the anvil **120** is in a closed position. The E-beam **178** can also include a sharpened cutting edge **182** which can be used to sever tissue as the E-beam **178** is advanced distally by the firing bar **172**. In operation, the E-beam **178** can also actuate, or fire, the staple cartridge **118**. The staple cartridge **118** can include a molded cartridge body **194** that holds a plurality of staples **191** resting upon staple drivers **192** within respective upwardly open staple cavities **195**. A wedge sled **190** is driven distally by the E-beam **178**, sliding upon a cartridge tray **196** that holds together the various components of the replaceable staple cartridge **118**. The wedge sled **190** upwardly cams the staple drivers **192** to force out the staples **191** into deforming contact with the anvil **120** while a cutting surface **182** of the E-beam **178** severs clamped tissue.

Further to the above, the E-beam **178** can include upper pins **180** which engage the anvil **120** during firing. The E-beam **178** can further include middle pins **184** and a bottom foot **186** which can engage various portions of the cartridge body **194**, cartridge tray **196** and elongate channel **198**. When a staple cartridge **118** is positioned within the elongate channel **198**, a slot **193** defined in the cartridge body **194** can be aligned with a slot **197** defined in the cartridge tray **196** and a slot **189** defined in the elongate channel **198**. In use, the E-beam **178** can slide through the aligned slots **193**, **197**, and **189** wherein, as indicated in FIG. **7**, the bottom foot **186** of the E-beam **178** can engage a groove running along the bottom surface of channel **198** along the length of slot **189**, the middle pins **184** can engage the top surfaces of cartridge tray **196** along the length of longitudinal slot **197**, and the upper pins **180** can engage the anvil **120**. In such circumstances, the E-beam **178** can space, or limit the relative movement between, the anvil **120** and the staple cartridge **118** as the firing bar **172** is moved distally to fire the staples from the staple cartridge **118** and/or incise the tissue captured between the anvil **120** and the staple cartridge **118**. Thereafter, the firing bar **172** and the E-beam **178** can be retracted proximally allowing the anvil **120** to be opened to release the two stapled and severed tissue portions (not shown).

FIGS. **7-9** also show a double pivot closure sleeve assembly **121** according to various embodiments. With particular reference to FIG. **7**, the double pivot closure sleeve assembly **121** includes a shaft closure tube section **128** having upper and lower distally projecting tangs **146**, **148**. An end effector closure tube section **126** includes a horseshoe aperture **124** and a tab **123** for engaging the opening tab **122** on the anvil **120**. The horseshoe aperture **124** and tab **123** engage tab **122** when the anvil **120** is opened. The closure tube section **126** is shown having upper **144** and lower (not visible) proximally projecting tangs. An upper double pivot link **130** includes upwardly projecting distal and proximal pivot pins **134**, **136** that engage respectively an upper distal pin hole **138** in the upper proximally projecting tang **144** and an upper proximal pin hole **140** in the upper distally projecting tang **146**. A lower double pivot link **132** includes downwardly projecting distal and proximal pivot pins (not shown in FIG. **7**, but see FIG. **8**) that engage respectively a lower distal pin hole in the lower proximally projecting tang and a lower proximal pin hole **142** in the lower distally projecting tang **148**.

In use, the closure sleeve assembly **121** is translated distally to close the anvil **120**, for example, in response to the actuation of the closure trigger **114**. The anvil **120** is closed by distally translating the closure tube section **126**, and thus the sleeve assembly **121**, causing it to strike a proximal surface on the anvil **120** located in FIG. **7** to the left of the tab **122**. As shown more clearly in FIGS. **7** and **8**, the anvil **120** is opened by proximally translating the tube section **126**, and sleeve assembly **121**, causing tab **123** and the horseshoe aperture **124** to contact and push against the tab **122** to lift the anvil **120**. In the anvil-open position, the double pivot closure sleeve assembly **121** is moved to its proximal position.

In operation, the clinician may articulate the end effector **102** of the instrument **100** relative to the shaft **104** about pivot **110** by pushing the control **112** laterally. From the neutral position, the clinician may articulate the end effector **102** to the left relative to the shaft **104** by providing a lateral force to the left side of the control **112**. In response to force, the articulation slide **208** may be pushed at least partially into the frame **212**. As the slide **208** is pushed into the frame **212**, the slot **210** as well as band portion **204** may be translated across the elongate shaft **104** in a transverse direction, for example, a direction substantially transverse, or perpendicular, to the longitudinal axis of the shaft **104**. Accordingly, a force is applied to band portion **204**, causing it to resiliently bend and/or displace from its initial pre-bent position toward the opposite side of the shaft **104**. Concurrently, band portion **202** is relaxed from its initial pre-bent position. Such movement of the band portion **204**, coupled with the straightening of band portion **202**, can apply a counter-clockwise rotational force at boss **206** which in turn causes the boss **206** and end effector **102** to pivot to the left about the articulation pivot **110** to a desired angle relative to the axis of the shaft **104** as shown in FIG. **12**. The relaxation of the band portion **202** decreases the tension on that band portion, allowing the band portion **204** to articulate the end effector **102** without substantial interference from the band portion **202**. It will be appreciated that the clinician may also articulate the end effector **102** to the right relative to the shaft **104** by providing a lateral force to the right side of the control **112**. This bends cable portion **202**, causing a clockwise rotational force at boss **206** which, in turn, causes the boss **206** and end effector to pivot to the right about articulation pivot **110**. Similar to the above, band portion **204** can be concurrently relaxed to permit such movement.

FIGS. **12** and **13** depict a motor-driven surgical cutting and fastening instrument **310**. This illustrated embodiment depicts an endoscopic instrument and, in general, the instrument **310** is described herein as an endoscopic surgical cutting and fastening instrument; however, it should be noted that the invention is not so limited and that, according to other embodiments, any instrument disclosed herein may comprise a non-endoscopic surgical cutting and fastening instrument. The surgical instrument **310** depicted in FIGS. **12** and **13** comprises a handle **306**, a shaft **308**, and an end effector **312** connected to the shaft **308**. In various embodiments, the end effector **312** can be articulated relative to the shaft **308** about an articulation joint **314**. Various means for articulating the end effector **312** and/or means for permitting the end effector **312** to articulate relative to the shaft **308** are disclosed in U.S. Pat. No. 7,753,245, entitled SURGICAL STAPLING INSTRUMENTS, which issued on Jul. 13, 2010, and U.S. Pat. No. 7,670,334, entitled SURGICAL INSTRUMENT HAVING AN ARTICULATING END EFFECTOR, which issued on Mar. 2, 2010, the entire disclosures of which are incorporated by reference herein. Various other means for articulating the end effector **312** are discussed in greater detail below. Similar to the above, the end effector **312** is configured to act as an endocutter for clamping, severing, and/or stapling tissue, although, in other embodiments, different types of end effectors may be used, such as end effectors for other types of surgical devices, graspers, cutters, staplers, clip appliers, access devices, drug/gene therapy devices, ultrasound, RF and/or laser devices, etc. Several RF devices may be found in U.S. Pat. No. 5,403,312, entitled ELECTROSURGICAL HEMOSTATIC DEVICE, which issued on Apr. 4, 1995, and U.S. patent application Ser. No. 12/031,573, entitled SURGICAL CUTTING AND FASTENING INSTRUMENT HAVING RF ELECTRODES, filed Feb. 14, 2008, the entire disclosures of which are incorporated by reference in their entirety.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping the handle **306** of the instrument **310**. Thus, the end effector **312** is distal with respect to the more proximal handle **306**. It will be further appreciated that, for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

The end effector **312** can include, among other things, a staple channel **322** and a pivotally translatable clamping member, such as an anvil **324**, for example. The handle **306** of the instrument **310** may include a closure trigger **318** and a firing trigger **320** for actuating the end effector **312**. It will be appreciated that instruments having end effectors directed to different surgical tasks may have different numbers or types of triggers or other suitable controls for operating the end effector **312**. The handle **306** can include a downwardly extending pistol grip **326** toward which the closure trigger **318** is pivotally drawn by the clinician to cause clamping or closing of the anvil **324** toward the staple channel **322** of the end effector **312** to thereby clamp tissue positioned between the anvil **324** and channel **322**. In other embodiments, different types of clamping members in addition to or lieu of the anvil **324** could be used. The handle **306** can further include a lock which can be configured to releasably hold the closure trigger **318** in its closed position. More details regarding embodiments of an exemplary closure system for closing (or clamping) the anvil **324** of the end effector **312** by retracting the closure trigger **318** are provided in U.S. Pat. No. 7,000,818, entitled SURGICAL STAPLING INSTRUMENT HAVING SEPARATE DISTINCT CLOSING AND FIRING SYSTEMS, which issued on Feb. 21, 2006, U.S. Pat. No. 7,422,139, entitled MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH TACTILE POSITION FEEDBACK, which issued on Sep. 9, 2008, and U.S. Pat. No. 7,464,849, entitled ELECTRO-MECHANICAL SURGICAL INSTRUMENT WITH CLOSURE SYSTEM AND ANVIL ALIGNMENT COMPONENTS, which issued on Dec. 16, 2008, the entire disclosures of which are incorporated by reference herein.

Once the clinician is satisfied with the positioning of the end effector **312**, the clinician may draw back the closure trigger **318** to its fully closed, locked position proximate to the pistol grip **326**. The firing trigger **320** may then be actuated, or fired. In at least one such embodiment, the firing trigger **320** can be farther outboard of the closure trigger **318** wherein the closure of the closure trigger **318** can move, or rotate, the firing trigger **320** toward the pistol grip **326** so that the firing trigger **320** can be reached by the operator using one hand. in various circumstances. Thereafter, the operator may pivotally draw the firing trigger **320** toward the pistol grip **312** to cause the stapling and severing of clamped tissue in the end effector **312**. Thereafter, the firing trigger **320** can be returned to its unactuated, or unfired, position (shown in FIGS. **1** and **2**) after the clinician relaxes or releases the force being applied to the firing trigger **320**. A release button on the handle **306**, when depressed, may release the locked closure trigger **318**. The release button may be implemented in various forms such as, for example, those disclosed in published U.S. Patent Application Pub. No. 2007/0175955, entitled SURGICAL CUTTING AND FASTENING INSTRUMENT WITH CLOSURE TRIGGER LOCKING MECHANISM, which was filed on Jan. 31, 2006, the entire disclosure of which is incorporated herein by reference in its entirety.

Further to the above, the end effector **312** may include a cutting instrument, such as knife, for example, for cutting tissue clamped in the end effector **312** when the firing trigger **320** is retracted by a user. Also further to the above, the end effector **312** may also comprise means for fastening the tissue severed by the cutting instrument, such as staples, RF electrodes, and/or adhesives, for example. A longitudinally movable drive shaft located within the shaft **308** of the instrument **310** may drive/actuate the cutting instrument and the fastening means in the end effector **312**. An electric motor, located in the handle **306** of the instrument **310** may be used to drive the drive shaft, as described further herein. In various embodiments, the motor may be a DC brushed driving motor having a maximum rotation of, approximately, 25,000 RPM, for example. In other embodiments, the motor may include a brushless motor, a cordless motor, a synchronous motor, a stepper motor, or any other suitable electric motor. A battery (or "power source" or "power pack"), such as a Li ion battery, for example, may be provided in the pistol grip portion **26** of the handle **6** adjacent to the motor wherein the battery can supply electric power to the motor via a motor control circuit. According to various embodiments, a number of battery cells connected in series may be used as the power source to power the motor. In addition, the power source may be replaceable and/or rechargeable.

As outlined above, the electric motor in the handle **306** of the instrument **310** can be operably engaged with the longitudinally-movable drive member positioned within the shaft **308**. Referring now to FIGS. **14-16**, an electric motor **342** can be mounted to and positioned within the pistol grip portion **326** of the handle **306**. The electric motor **342** can include a rotatable shaft operably coupled with a gear reducer assembly **370** wherein the gear reducer assembly **370** can include, among other things, a housing **374** and an output pinion gear **372**. In certain embodiments, the output pinion gear **372** can be directly operably engaged with a longitudinally-movable drive member **382** or, alternatively, operably engaged with the drive member **382** via one or more intermediate gears **386**. The intermediate gear **386**, in at least one such embodiment, can be meshingly engaged with a set, or rack, of drive teeth **384** defined in the drive member **382**. In use, the electric motor **342** can be drive the drive member distally, indicated by an arrow D (FIG. **15**), and/or proximally, indicated by an arrow D (FIG. **16**), depending on the direction in which the electric motor **342** rotates the intermediate gear **386**. In use, a voltage polarity provided by the battery can operate the electric motor **342** in a clockwise direction wherein the voltage polarity applied to the electric motor by the battery can be reversed in order to operate the electric motor **342** in a counter-clockwise direction. The handle **306** can include a switch which can be configured to reverse the polarity applied to the electric motor **342** by the battery. The handle **306** can also include a sensor **330** configured to detect the position of the drive member **382** and/or the direction in which the drive member **382** is being moved.

As indicated above, the surgical instrument **310** can include an articulation joint **314** about which the end effector **312** can be articulated. The instrument **310** can further include an articulation lock which can be configured and operated to selectively lock the end effector **312** in position. In at least one such embodiment, the articulation lock can extend from the proximal end of the shaft **308** to the distal end of the shaft **308** wherein a distal end of the articulation lock can engage the end effector **312** to lock the end effector **312** in position. Referring again to FIGS. **12** and **13**, the instrument **310** can further include an articulation control **316** which can be engaged with a proximal end of the articulation lock and can be configured to operate the articulation lock between a locked state and an unlocked state. In use, the articulation control **316** can be pulled proximally to unlock the end effector **312** and permit the end effector **312** to rotate about the articulation joint **314**. After the end effector **312** has been suitably articulated, the articulation control **316** can be moved distally to re-lock the end effector **312** in position. In at least one such embodiment, the handle **306** can further include a spring and/or other suitable biasing elements configured to bias the articulation control **316** distally and to bias the articulation lock into a locked configuration with the end effector **312**. If the clinician desires, the clinician can once again pull the articulation control **316** back, or proximally, to unlock the end effector **312**, articulate the end effector **312**, and then move the articulation control **316** back into its locked state. In such a locked state, the end effector **312** may not articulate relative to the shaft **308**.

As outlined above, the surgical instrument **310** can include an articulation lock configured to hold the end effector **312** in position relative to the shaft **308**. As also outlined above, the end effector **312** can be rotated, or articulated, relative to the shaft **308** when the articulation lock is in its unlocked state. In such an unlocked state, the end effector **312** can be positioned and pushed against soft tissue and/or bone, for example, surrounding the surgical site within the patient in order to cause the end effector **312** to articulate relative to the shaft **308**. In certain embodiments, the articulation control **316** can comprise an articulation switch or can be configured to operate an articulation switch which can selectively permit and/or prevent the firing trigger **320** from operating the electric motor **342**. For instance, such an articulation switch can be placed in series with the electric motor **342** and a firing switch operably associated with the firing trigger **320** wherein the articulation switch can be in a closed state when the articulation control **316** is in a locked state. When the articulation control **316** is moved into an unlocked state, the articulation control **316** can open the articulation switch thereby electrically decoupling the operation of the firing trigger **320** and the operation of the electric motor **342**. In such circumstances, the firing drive of the instrument **310** cannot be fired while the end effector **312** is in an unlocked state and is articulatable relative to the shaft **308**. When the articulation control **316** is returned to its locked state, the articulation control **316** can re-close the articulation switch which can then electrically couple the operation of the firing trigger **320** with the electric motor **342**. Various details of one or more surgical stapling instruments are disclosed in U.S. patent application Ser. No. 12/647,100, entitled MOTOR-DRIVEN SURGICAL CUTTING INSTRUMENT WITH ELECTRIC ACTUATOR DIRECTIONAL CONTROL ASSEMBLY, which issued on Jul. 17, 2012 as U.S. Pat. No. 8,220,688, the entire disclosure of which is incorporated by reference herein.

Turning now to FIGS. **17-29**, a surgical instrument **400** can comprise a handle **403**, a shaft **404** extending from the handle **403**, and an end effector **402** extending from the shaft **404**. As the reader will note, portions of the handle **403** have been removed for the purposes of illustration; however, the handle **403** can include a closure trigger and a firing trigger similar to the closure trigger **114** and the firing trigger **116** depicted in FIG. **1**, for example. As will be described in greater detail below, the firing trigger **116** can be operably coupled with a firing drive including a firing member **470** extending through the shaft **404** wherein the operation of the firing trigger **116** can advance the firing member **470** distally toward the end effector **402**. As will also be described in greater detail below, the surgical instrument **400** can further include an articulation drive which can be selectively coupled with the firing member **470** such that, when the firing member **470** is motivated by the firing trigger **116** and/or by a separate articulation trigger and/or button, for example, the articulation drive can be driven by the firing member **470** and the articulation drive can, in turn, articulate the end effector **402** about an articulation joint **410**.

Turning now to FIG. **17**, the reader will note that the end effector **402** of the surgical instrument **400** is illustrated in an open configuration. More particularly, a first jaw of the end effector **402** comprising an anvil **420** is illustrated in an open position relative to a channel **498** of a second jaw of the end effector **402**. Similar to the above, the channel **498** can be configured to receive and secure a staple cartridge therein.

Turning now to FIG. **20** which also illustrates the end effector **420** in an open configuration, the handle **403** of the surgical instrument **400** can include an articulation lock actuator **409** which can be moved between a distal, or locked, position in which the end effector **402** is locked in position relative to the shaft **404** and a proximal, or unlocked, position in which the end effector **402** can be articulated relative to the shaft **404** about the articulation joint **410**. Although the end effector **402** and the shaft **404** are illustrated in FIG. **20** as being aligned in a straight configuration, the articulation lock actuator **409** is illustrated in its retracted, unlocked position and, as a result, the end effector **402** can be articulated relative to the shaft **404**. Referring to FIGS. **19**, **24**A and **24**B, the articulation lock actuator **409** (FIG. **21**) can be operably coupled with an articulation lock **443** wherein the articulation lock actuator **409** can move the articulation lock **443** between a distal position (FIG. **24**A) in which the articulation lock **443** is engaged with a proximal lock member **407** of the end effector **402** and a proximal position (FIG. **24**B) in which the articulation lock **443** is disengaged from the end effector **402**. As the reader will appreciate, the distal, locked, position of the articulation lock actuator **409** corresponds with the distal position of the articulation lock **443** and the proximal, unlocked, position of the articulation lock actuator **409** corresponds with the proximal position of the articulation lock **443**. Turning now to FIG. **19**, the articulation lock **443** is coupled to the articulation lock actuator **409** by an articulation lock bar **440** which comprises a distal end **442** engaged with the articulation lock **443**, as better seen in FIG. **24**A, and a proximal end **441** engaged with the articulation lock actuator **409**, as better seen in FIG. **22**. As illustrated in FIGS. **24**A and **24**B, the articulation lock **443** can comprise one or more teeth **445** which can be configured to meshingly engage one or more teeth **446** defined around the perimeter of the proximal lock member **407**, for example. Referring primarily to FIG. **19**, the shaft **404** can further comprise a biasing member, such as a spring **444**, for example, which can be configured to bias the teeth **445** of the articulation lock **443** into engagement with the teeth **446** of the proximal lock member **407** of the end effector **402**. Similarly, the handle **403** can further comprise a biasing member positioned within the cavity **488** (FIG. **23**) defined between the articulation lock actuator **409** and the frame **480** such that the biasing member can push the articulation lock actuator **409** towards its distal, locked, position.

As illustrated in FIG. **17**, the articulation lock actuator **409** can be comprised of two nozzle halves, or portions, **411***a* and **411***b* wherein, as the reader will note, the nozzle portion **411***b* has been removed from FIGS. **18-27** for the purposes of illustration. As also illustrated in FIG. **17**, the articulation lock actuator **409** can comprise a plurality of finger hooks **413** which can be grasped by the surgeon, or other clinician, in order to retract the articulation lock actuator **409** into its proximal, unlocked, configuration. The articulation lock actuator **409**, referring again to FIG. **20**, can further include a detent assembly **452** which can be configured to bias a detent member **457** against the frame of the shaft **404** or the frame of the handle **403**. More particularly, the shaft **404** can comprise a shaft frame **454** extending from a handle frame **480** wherein the detent assembly **452** can be configured to bias the detent member **457** against the shaft frame **454**. Referring to FIG. **19**, the shaft frame **454** can include a detent channel **453** defined therein which can be aligned with the detent member **457** such that, as the articulation lock actuator **409** is slid between its locked and unlocked positions described above, the detent member **457** can slide within the detent channel **453**. The detent assembly **452**, referring again to FIG. **20**, can include a stationary frame portion **458** which can define a



threaded aperture configured to receive an adjustable threaded member **459**. The adjustable threaded member **459** can include an internal aperture wherein at least a portion of the detent member **457** can be positioned within the internal aperture and wherein the detent member **457** can be biased to the end of the internal aperture by a spring, for example, positioned intermediate the detent member **457** and a closed end of the internal aperture, for example. As illustrated in FIG. **19**, the proximal end of the detent channel **453** can comprise a detent seat **455** which can be configured to removably receive the detent member **457** when the articulation lock actuator **409** has reached its proximal, unlocked, position. In various circumstances, the detent member **457**, the detent seat **455**, and the biasing spring positioned in the adjustable threaded member **459** can be sized and configured such that the detent assembly **452** can releasably hold the articulation lock actuator **409** in its proximal, unlocked, position. As described in greater detail below, the articulation lock actuator **409** can be held in its proximal, unlocked, position until the end effector **402** has been suitably articulated. At such point, the articulation lock actuator **409** can be pushed forward to disengage the detent member **457** from the detent seat **455**. As the reader will appreciate, referring primarily to FIG. **20**, the adjustable threaded member **459** can be rotated downwardly toward the shaft frame **454** in order to increase the force needed to unseat the detent member **457** from the detent seat **455** while the adjustable threaded member **459** can be rotated upwardly away from the shaft frame **454** in order to decrease the force needed to unseat the detent member **457** from the detent seat **455**. As also illustrated in FIG. **20**, the articulation lock actuator **409** can comprise an access port **418** which can be utilized to access and rotate the threaded member **459**.

As discussed above, the articulation lock actuator **409** is in a retracted, unlocked, position in FIG. **20** and the end effector **402** is in an unlocked configuration, as illustrated in FIG. **24**B. Referring now to FIGS. **19** and **20**, the surgical instrument **400** further comprises an articulation driver **460** which can be pushed distally to rotate the end effector **402** about the articulation joint **410** in a first direction and pulled proximally to rotate the end effector **402** about the articulation joint in a second, or opposite, direction, as illustrated in FIG. **21**. Upon comparing FIGS. **20** and **21**, the reader will note that the articulation driver **460** has been pulled proximally by the firing member **470**. More specifically, an intermediate portion **475** of the firing member **470** can comprise a notch, or slot, **476** defined therein which can be configured to receive a proximal end **461** of the articulation driver **460** such that, when the firing member **470** is pulled proximally, the firing member **470** can pull the articulation driver **460** proximally as well. Similarly, when the firing member **470** is pushed distally, the firing member **470** can push the articulation driver **460** distally. As also illustrated in FIGS. **20** and **21**, the articulation driver **460** can comprise a distal end **462** engaged with a projection **414** extending from the proximal lock member **407**, for example, which can be configured to transmit the proximal and distal articulation motions of the articulation driver **460** to the end effector **102**. Referring primarily to FIGS. **18-20**, the handle **404** can further comprise a proximal firing member portion **482** of the firing member **470** including a distal end **481** engaged with a proximal end **477** of the intermediate portion **475** of the firing member **470**. Similar to the above, the handle **403** can include an electric motor comprising an output shaft and a gear operably engaged with the output shaft wherein the gear can be operably engaged with a longitudinal set of teeth **484** defined in a surface of the firing member portion **482**. In use, further to the above, the electric motor can be operated in a first direction to advance the firing member **470** distally and a second, or opposite, direction to retract the firing member **470** proximally. Although not illustrated, the handle **403** can further comprise a switch which can be positioned in a first condition to operate the electric motor in its first direction, a second condition to operate the electric motor in its second direction, and/or a neutral condition in which the electric motor is not operated in either direction. In at least one such embodiment, the switch can include at least one biasing member, such as a spring, for example, which can be configured to bias the switch into its neutral condition, for example. Also, in at least one such embodiment, the first condition of the articulation switch can comprise a first position of a switch toggle on a first side of a neutral position and the second condition of the articulation switch can comprise a second position of the switch toggle on a second, or opposite, side of the neutral position, for example.

In various circumstances, further to the above, the articulation switch can be used to make small adjustments in the position of the end effector **402**. For instance, the surgeon can move the articulation switch in a first direction to rotate the end effector **402** about the articulation joint in a first direction and then reverse the movement of the end effector **402** by moving the articulation switch in the second direction, and/or any other suitable combinations of movements in the first and second directions, until the end effector **402** is positioned in a desired position. Referring primarily to FIGS. **19**, **24**A, and **24**B, the articulation joint **410** can include a pivot pin **405** extending from a shaft frame member **451** and, in addition, an aperture **408** defined in the proximal lock member **407** which is configured to closely receive the pivot pin **405** therein such that the rotation of the end effector **402** is constrained to rotation about an articulation axis **406**, for example. Referring primarily to FIG. **19**, the distal end of the shaft frame **454** can include a recess **456** configured to receive the shaft frame member **451** therein. As will be described in greater detail below, the shaft **404** can include an outer sleeve which can be slid relative to the shaft frame **454** in order to close the anvil **420**. Referring primarily to FIGS. **19-21**, the outer sleeve of the shaft **410** can comprise a proximal portion **428** and a distal portion **426** which can be connected to one another by articulation links **430** and **432**. When the outer sleeve is slid relative to the articulation joint **410**, the articulation links **430** can accommodate the angled relative movement between the distal portion **426** and the proximal portion **428** of the outer sleeve when the end effector **402** has been articulated, as illustrated in FIG. **21**. In various circumstances, the articulation links **430** and **432** can provide two or more degrees of freedom at the articulation joint **410** in order to accommodate the articulation of the end effector **402**. The reader will also note that the articulation joint **410** can further include a guide **401** which can be configured to receive a distal cutting portion **472** of the firing member **470** therein and guide the distal cutting portion **472** as it is advanced distally and/or retracted proximally within and/or relative to the articulation joint **410**.

As outlined above, the firing member **470** can be advanced distally in order to advance the articulation driver **460** distally and, as a result, rotate the end effector **402** in a first direction and, similarly, the firing member **470** can be retracted proximally in order to retract the articulation driver **460** proximally and, as a result, rotate the end effector **402** in an opposite direction. In some circumstances, however, it may be undesirable to move, or at least substantially move, the distal cutting portion **472** of the firing member **470** when the firing member **470** is being utilized to articulate the end effector **402**. Turning now to FIGS. **19-21**, the intermediate portion **475** of the firing member **470** can comprise a longitudinal slot **474** defined in the distal end thereof which can be configured to receive the proximal end **473** of the distal cutting portion **472**. The longitudinal slot **474** and the proximal end **473** can be sized and configured to permit relative movement therebetween and can comprise a slip joint **471**. The slip joint **471** can permit the intermediate portion **475** of the firing drive **470** to be moved to articulate the end effector **402** without moving, or at least substantially moving, the distal cutting portion **472**. Once the end effector **402** has been suitably oriented, the intermediate portion **475** can be advanced distally until a proximal sidewall of the longitudinal slot **474** comes into contact with the proximal end **473** in order to advance the distal cutting portion **472** and fire the staple cartridge positioned within the channel **498**, as described in greater detail further below. Referring primarily to FIG. **19**, the shaft frame **454** can comprise a longitudinal slot **469** defined therein which can be configured to slidably receive the articulation driver **460** and, similarly, the proximal portion **428** of the outer shaft sleeve can comprise a longitudinal opening **425** configured to accommodate the relative movement between the articulation driver **460** and the outer sleeve of the shaft **404** described above.

Further to the above, the articulation lock actuator **409** can be configured to bias the proximal portion **461** of the articulation driver **460** toward the drive member **470** when the articulation lock actuator **409** is in its proximal, unlocked, position. More particularly, in at least one such embodiment, the inner surface of the articulation lock actuator **409** can comprise a cam which can engage a lateral side **466** of the proximal portion **461** and bias the proximal portion **461** into engagement with the slot **476** defined in the intermediate portion **475** of the drive member **470**. When the articulation lock actuator **409** is moved back into its distal, locked, position, the articulation lock actuator **409** may no longer bias the proximal portion **461** inwardly toward the drive member **470**. In at least one such embodiment, the handle **403** and/or the shaft **404** can comprise a resilient member, such as a spring, for example, which can be configured to bias the proximal portion **461** outwardly away from the firing member **470** such that the proximal portion **461** is not operably engaged with the slot **476** unless the biasing force of the resilient member is overcome by the articulation lock actuator **409** when the articulation lock actuator **409** is moved proximally into its unlocked position, as described above. In various circumstances, the proximal portion **461** and the slot **476** can comprise a force-limiting clutch.

Once the end effector **402** has been articulated into the desired orientation, further to the above, the closure trigger **114** can be actuated to move the anvil **420** toward its closed position, as illustrated in FIG. **22**. More particularly, the closure trigger **114** can advance the outer sleeve of the shaft **410** distally such that the distal portion **426** of the outer sleeve can push the anvil **420** distally and downwardly, for example. The anvil **420** can comprise projections **497** extending from opposite sides of the anvil **420** which can each be configured to slide and rotate within elongate slots **499** defined in the cartridge channel **498**. The anvil **420** can further comprise a projection **496** extending upwardly therefrom which can be positioned within an aperture **495** defined in the distal portion **426** of the outer sleeve wherein a sidewall of the aperture **495** can contact the projection **496** as the distal portion **426** is advanced distally to move the anvil **420** toward the cartridge channel **498**. The actuation of the closure drive, further to the above, can also move the articulation lock actuator **409** from its proximal, unlocked, position (FIGS. **20-22**) into its distal, locked, position (FIG. **23**). More specifically, the closure drive can be configured to advance a closure drive carriage **415** distally which can contact a collar **450** mounted within the articulation actuator **409**, as illustrated in FIG. **22**. As illustrated in FIGS. **19** and **22**, the collar **450** can comprise opposing portions, or halves, which can be assembled together such that the opposing portions of the collar **450** can surround the shaft **404**. The collar **450** can also support the detent assembly **452**, which is discussed above, and can include a mounting portion engaged with the proximal end **441** of the articulation lock bar **440**, which is also discussed above. In any event, the closure drive carriage **415** can contact the collar **450** and slide the articulation lock actuator **409** distally and, further to the above, displace the detent member **457** from the detent seat **455**, referring to FIG. **19**, into the detent channel **453** such that the articulation lock actuator **409** can be pushed into its locked position and the articulation lock **443** can be moved into engagement with the proximal lock portion **407** to lock the end effector **402** in position, as illustrated in FIG. **23**. At such point, the closure drive carriage **415** can prevent the end effector **402** from being unlocked and articulated until the closure drive and the anvil **420** is reopened and the closure drive carriage **415** is moved proximally, as described in greater detail further below.

Referring now to FIG. **25**, the actuation of the closure drive by the closure drive actuator **114** and the distal advancement of the outer sleeve **428** of the shaft **410** can also operably disengage the articulation driver **460** from the firing drive **470**. Upon reviewing FIGS. **20** and **21** once again, the reader will note that the outer sleeve **428** includes a window **424** defined therein within which a rotatable cam member **465** can be positioned. The cam member **465** can comprise a first end rotatably pinned or coupled to the shaft frame **454** and a second end configured to rotate relative to the pinned end of the cam member **465** while, in other embodiments, the cam member **465** can comprise any suitable shape. When the outer sleeve **428** is in its proximal position and the anvil **420** is in its open configuration, the cam member **465** can be in a first position which permits the proximal end **461** of the articulation driver **460** to be engaged with the slot **476** defined in the firing member **470**; however, when the outer sleeve **428** is advanced distally, a sidewall of the window **424** can engage the cam member **465** and lift the second end of the cam member **465** away from the shaft frame **454** into a second position. In this second position, the cam member **465** can move the proximal end **461** of the articulation driver **460** away from the firing drive **470** such that the proximal end **461** is no longer positioned within the slot **476** defined in the firing drive **470**. Thus, when the closure drive has been actuated to close the anvil **420**, the closure drive can push the articulation lock actuator **409** into its distal, locked, configuration, the articulation lock actuator **409** can push the articulation lock **445** into a locked configuration with the end effector **402**, and, in addition, the closure drive can operably disconnect the articulation driver **460** from the firing drive **470**. At such point in the operation of the surgical instrument **400**, the actuation of the firing drive **470** will not articulate the end effector **402** and the firing drive **470** can move independently of the articulation driver **460**.

Turning now to FIG. **26**, as mentioned above, the firing drive **470** can be advanced distally to eject staples from a staple cartridge positioned within the channel **498** of the end effector **402** and to deform the staples against the anvil **420**. As outlined above, the firing drive **470** can further comprise a cutting member which can be configured to transect the tissue captured within the end effector **402**. As also mentioned above, the electric motor within the handle **403** can be operated by the firing actuator **116** in order to advance the firing member **470** distally wherein, in various circumstances, the electric motor can be operated until the distal cutting portion **472** of the firing member **470** reaches the distal end of the staple cartridge and/or any other suitable position within the staple cartridge. In any event, the rotation of the electric motor can be reversed to retract the firing member **470** proximally, as illustrated in FIG. **27**. In various circumstances, the electric motor can retract the proximal drive portion **482** and the intermediate portion **475** until the distal sidewall of the longitudinal slot **474** defined in the intermediate portion **475** comes into contact with the proximal end **473** of the distal cutting member **472**. At such point, the further retraction of the proximal drive portion **482** and the intermediate portion **475** will retract the distal cutting member **472** proximally. In various circumstances, the electric motor can be operated until the slot **476** defined in the intermediate portion **475** of the firing member **470** is realigned with the proximal portion **461** of the articulation driver **460**; however, as the closure sleeve **428** is still in a distally advanced position, the cam member **465** may still be biasing the articulation driver **460** out of engagement with the firing member **470**. In order to permit the articulation driver **460** to be re-engaged with the firing member **470**, in such circumstances, the closure drive would have to be re-opened to bring the window **424** defined in the outer sleeve portion **428** into alignment with the cam member **465** such that the cam member **465** can be pivoted inwardly toward the shaft frame **454** into its first position. In various circumstances, the articulation driver **460** can be resiliently flexed out of engagement with the firing member **470** such that, when the cam member **465** is permitted to move back into its first position, the articulation driver **460** can resiliently flex inwardly toward the shaft frame **454** to re-engage the proximal portion **461** of the articulation driver **460** with the slot **476** defined in the intermediate portion **475** of the drive member **470**. In various embodiments, the surgical instrument **400** can further comprise a biasing member which can be configured to bias the proximal portion **461** back into engagement with the intermediate portion **475**.

The reader will note that the intermediate portion **475** of the firing member **470** has been retracted proximally in FIG. **27** such that the slot **476** defined in the intermediate portion **475** is positioned proximally with respect to the proximal portion **461** of the articulation driver **460**. In such circumstances, as a result, the proximal portion **461** may not be operably reconnected to the firing member **470** until the intermediate portion **475** is advanced distally to align the slot **476** with the proximal portion **461**. Such circumstances may arise as a result of the relative slip between the intermediation portion **475** and the cutting member portion **472** of the firing member **470** created by the slip joint **471** which can be addressed by momentarily re-actuating the electric motor in the first direction, for example.

Referring again to FIG. **27**, the firing member **470** may be in a retracted or reset position, however, the closure drive is still in an actuated, or closed, configuration which can prevent the anvil **420** from being re-opened and the end effector **402** from being re-articulated. When the closure drive is released, referring now to FIG. **28**, the closure drive carriage **415** can be retracted into a proximal position in which the closure sleeve including portions **426** and **428** are pulled proximally as well. Referring again to FIG. **19**, the proximal sleeve portion **428** can include a proximal end **417** which can be engaged with the closure drive carriage **415** such that the proximal sleeve portion **428** and the closure drive carriage **415** move together in the distal direction and/or the proximal direction. In any event, further to the above, the proximal movement of the distal sleeve portion **426** can cause the distal sidewall of the aperture **495** to engage the projection **496** extending from the anvil **420** in order to pivot the anvil **420** into its open position, as illustrated in FIG. **29**. Furthermore, the proximal movement of the closure drive carriage **415** can unlock the articulation lock actuator **409** such that the articulation lock actuator **409** can be moved into is proximal, unlocked, position which can, as a result, pull the articulation lock **443** proximally to compress the spring **444** and unlock the end effector **402**. As described above, the end effector **402** can be then articulated about the articulation joint **410** and the operation of the surgical instrument **400** described above can be repeated. Referring primarily to FIGS. **18-20**, the handle **404** can further comprise a switch **408** mounted to the handle frame **480** which can be configured to detect whether the articulation lock actuator **409** is in its proximal, unlocked, position. In some embodiments, the switch **408** can be operably coupled with an indicator in the handle **404**, such as light, for example, which can indicate to the operator of the surgical instrument **400** that the end effector **402** is in an unlocked condition and that the operator may utilize the articulation switch to articulate the end effector **402**, for example.

As described above in connection with the embodiment of FIG. **17**, the surgical instrument **400** can comprise an articulation lock system configured to lock and unlock the end effector **402** and a closure drive configured to open and close the anvil **420** of the end effector **402**. Although these two systems of the surgical instrument **400** interact in several respects, which are described above, the systems can be actuated independently of one another in other respects. For instance, the articulation lock actuator **409** and the end effector lock **443** can be actuated without closing the anvil **420**. In this embodiment of the surgical instrument **400**, the closure drive is operated independently to close the anvil **420**. Turning now to FIGS. **30-32**, the surgical instrument **400** can include an alternate arrangement in which the closure drive is actuated to, one, close the anvil **420** and, two, lock the end effector **402** in position. Referring primarily to FIGS. **31** and **32**, the shaft **404** can comprise an articulation lock bar **540** which can be moved between a proximal, unlocked, position (FIG. **31**) in which the end effector **402** can be articulated about the articulation joint **410** and a distal, locked, position (FIG. **32**) in which the end effector **402** can be locked in position. Similar to the articulation lock bar **440**, the articulation lock bar **540** can include a distal end **542** which is operably engaged with the articulation lock **443** such that, when the articulation lock bar **540** is pulled proximally, the articulation lock **443** can be pulled proximally. Similarly, when the articulation lock bar **540** is pushed distally, the articulation lock **443** can be pushed distally as well. In contrast to the articulation lock bar **440** which is pushed distally and pulled proximally by the articulation lock actuator **409**, as described above, the articulation lock bar **540** can be pushed distally and pulled proximally by the closure sleeve **428**. More particularly, the proximal end **541** of the articulation lock bar **540** can comprise a hook **547** which, when the closure sleeve **428** is pulled proximally, can catch a portion of the closure sleeve **428** and be pulled proximally with the closure sleeve **428**. In such circumstances, the sleeve **428** can pull the articulation lock bar **540** into an unlocked condition. As the reader will note, the closure sleeve **428** can include a window **549** within which the proximal end **541** of the articulation lock bar **540** can be positioned. When the closure sleeve **428** is pushed distally, further to the above, a proximal sidewall **548** of the window **549** can contact the proximal end **541** and push the articulation lock bar **540** and the articulation lock **443** distally in order to lock the end effector **402** in position.

As described herein, it may be desirable to employ surgical systems and devices that may include reusable portions that are configured to be used with interchangeable surgical components. Referring to FIG. **33**, for example, there is shown a surgical system, generally designated as **1000**, that, in at least one form, comprises a surgical instrument **1010** that may or may not be reused. The surgical instrument **1010** can be employed with a plurality of interchangeable shaft assemblies **1200**, **1200'**, **1200"**. The interchangeable shaft assemblies **1200**, **1200'**, **1200"** may have a surgical end effector **1300**, **1300'**, **1300"** operably coupled thereto that is configured to perform one or more surgical tasks or procedures. For example, each of the surgical end effectors **1300**, **1300'**, **1300"** may comprise a surgical cutting and fastening device that is configured to operably support a surgical staple cartridge therein. Each of the shaft assemblies may employ end effectors that are adapted to support different sizes and types of staple cartridges, have different shaft lengths, sizes, and types, etc. While the present Figures illustrate end effectors that are configured to cut and staple tissue, various aspects of the surgical system **1000** may also be effectively employed with surgical instruments that are configured to apply other motions and forms of energy such as, for example, radio frequency (RF) energy, ultrasonic energy and/or motion, to interchangeable shaft-mounted end effector arrangements that are used in various surgical applications and procedures. Furthermore, the end effectors, shaft assemblies, handles, surgical instruments, and/or surgical instrument systems can utilize any suitable fastener, or fasteners, to fasten tissue. For instance, a fastener cartridge comprising a plurality of fasteners removably stored therein can be removably inserted into and/or attached to the end effector of a shaft assembly. In various circumstances, a shaft assembly can be selected to be attached to a handle of a surgical instrument and a fastener cartridge can be selected to be attached to the shaft assembly.

The surgical instrument **1010** depicted in the FIG. **33** comprises a housing **1040** that consists of a handle **1042** that is configured to be grasped, manipulated and actuated by the clinician. As the present Detailed Description proceeds, however, it will be understood that the various unique and novel arrangements of the various forms of interchangeable shaft assemblies disclosed herein may also be effectively employed in connection with robotically-controlled surgical systems. Thus, the term "housing" may also encompass a housing or similar portion of a robotic system that houses or otherwise operably supports at least one drive system that is configured to generate and apply at least one control motion which could be used to actuate the interchangeable shaft assemblies disclosed herein and their respective equivalents. The term "frame" may refer to a portion of a handheld surgical instrument. The term "frame" may also represent a portion of a robotically controlled surgical instrument and/or a portion of the robotic system that may be used to operably control a surgical instrument. For example, the interchangeable shaft assemblies disclosed herein may be employed with various robotic systems, instruments, components and methods disclosed in U.S. Pat. No. 9,072,535. U.S. patent application Ser. No. 13/118,241, entitled SURGICAL STAPLING INSTRUMENTS WITH ROTATABLE STAPLE DEPLOYMENT ARRANGEMENTS, which issued on Jul. 7, 2015 as U.S. Pat. No. 9,072,535, is incorporated by reference herein in its entirety.

FIG. **34** illustrates the surgical instrument **1010** with an interchangeable shaft assembly **1200** operably coupled thereto. In the illustrated form, the surgical instrument includes a handle **1042**. In at least one form, the handle **1042** may comprise a pair of interconnectable housing segments

1044, 1046 that may be interconnected by screws, snap features, adhesive, etc. See FIG. 35. In the illustrated arrangement, the handle housing segments 1044, 1046 cooperate to form a pistol grip portion 1048 that can be gripped and manipulated by the clinician. As will be discussed in further detail below, the handle 1042 operably supports a plurality of drive systems therein that are configured to generate and apply various control motions to corresponding portions of the interchangeable shaft assembly that is operably attached thereto.

The handle 1042 may further include a frame 1080 that operably supports a plurality of drive systems. For example, the frame 1080 can operably support a first or closure drive system, generally designated as 1050, which may be employed to apply a closing and opening motions to the interchangeable shaft assembly 1200 that is operably attached or coupled thereto. In at least one form, the closure drive system 1050 may include an actuator in the form of a closure trigger 1052 that is pivotally supported by the frame 1080. More specifically, as illustrated in FIG. 35, the closure trigger 1052 may be pivotally supported by frame 1080 such that when the clinician grips the pistol grip portion 1048 of the handle 1042, the closure trigger 1052 may be easily pivoted from a starting or unactuated position to an actuated position and more particularly to a fully compressed or fully actuated position. The closure trigger 1052 may be biased into the unactuated position by spring or other biasing arrangement (not shown). In various forms, the closure drive system 1050 further includes a closure linkage assembly 1060 that is pivotally coupled to the closure trigger 1052. As can be seen in FIG. 35, the closure linkage assembly 1060 may include a closure trigger 1052 that is pivotally coupled to a closure link 1064 that has a pair of laterally extending attachment lugs or portions 1066 protruding therefrom. The closure link 1064 may also be referred to herein as an "attachment member".

Still referring to FIG. 35, it can be observed that the closure trigger 1052 may have a locking wall 1068 thereon that is configured to cooperate with a closure release assembly 1070 that is pivotally coupled to the frame 1080. In at least one form, the closure release assembly 1070 may comprise a release button assembly 1072 that has a distally protruding cam follower arm 1074 formed thereon. The release button assembly 1072 may be pivoted in a counterclockwise direction by a release spring 1076. As the clinician depresses the closure trigger 1052 from its unactuated position towards the pistol grip portion 1048 of the handle 1042, the closure link 1062 pivots upward to a point wherein the cam follower arm 1072 drops into retaining engagement with the locking wall 1068 on the closure link 1062 thereby preventing the closure trigger 1052 from returning to the unactuated position. Thus, the closure release assembly 1070 serves to lock the closure trigger 1052 in the fully actuated position. When the clinician desires to unlock the closure trigger 1052 to permit it to be biased to the unactuated position, the clinician simply pivots the closure release button assembly 1072 such that the cam follower arm 1074 is moved out of engagement with the locking wall 1068 on the closure trigger 1052. When the cam follower arm 1074 has been moved out of engagement with the closure trigger 1052, the closure trigger 1052 may pivot back to the unactuated position. Other closure trigger locking and release arrangements may also be employed.

In at least one form, the handle 1042 and the frame 1080 may operably support another drive system referred to herein as firing drive system 1100 that is configured to apply firing motions to corresponding portions of the interchangeable shaft assembly attached thereto. The firing drive system may also be referred to herein as a "second drive system". The firing drive system 1100 may employ an electric motor 1102, located in the pistol grip portion 1048 of the handle 1042. In various forms, the motor 1102 may be a DC brushed driving motor having a maximum rotation of, approximately, 25,000 RPM, for example. In other arrangements, the motor may include a brushless motor, a cordless motor, a synchronous motor, a stepper motor, or any other suitable electric motor. A battery 1104 (or "power source" or "power pack"), such as a Li ion battery, for example, may be coupled to the handle 1042 to supply power to a control circuit board assembly 1106 and ultimately to the motor 1102. FIG. 34 illustrates a battery pack housing 1104 that is configured to be releasably mounted to the handle 1042 for supplying control power to the surgical instrument 1010. A number of battery cells connected in series may be used as the power source to power the motor. In addition, the power source may be replaceable and/or rechargeable.

As outlined above with respect to other various forms, the electric motor 1102 can include a rotatable shaft (not shown) that operably interfaces with a gear reducer assembly 1108 that is mounted in meshing engagement with a with a set, or rack, of drive teeth 1112 on a longitudinally-movable drive member 1110. In use, a voltage polarity provided by the battery can operate the electric motor 1102 in a clockwise direction wherein the voltage polarity applied to the electric motor by the battery can be reversed in order to operate the electric motor 1102 in a counter-clockwise direction. When the electric motor 1102 is rotated in one direction, the drive member 1110 will be axially driven in the distal direction "D". When the motor 1102 is driven in the opposite rotary direction, the drive member 1110 will be axially driven in a proximal direction "P". See, for example, FIG. 35. The handle 1042 can include a switch which can be configured to reverse the polarity applied to the electric motor 1102 by the battery. As with the other forms described herein, the handle 1042 can also include a sensor that is configured to detect the position of the drive member 1110 and/or the direction in which the drive member 1110 is being moved.

Actuation of the motor 1102 can be controlled by a firing trigger 1120 that is pivotally supported on the handle 1042. The firing trigger 1120 may be pivoted between an unactuated position and an actuated position. The firing trigger 1120 may be biased into the unactuated position by a spring (not shown) or other biasing arrangement such that when the clinician releases the firing trigger 1120, it may be pivoted or otherwise returned to the unactuated position by the spring or biasing arrangement. In at least one form, the firing trigger 1120 can be positioned "outboard" of the closure trigger 1052 as was discussed above. In at least one form, a firing trigger safety button 1122 may be pivotally mounted to the closure trigger 1052. As can be seen in FIGS. 35 and 36, for example, the safety button 1122 may be positioned between the firing trigger 1120 and the closure trigger 1052 and have a pivot arm 1124 protruding therefrom. As shown in FIG. 38, when the closure trigger 1052 is in the unactuated position, the safety button 1122 is contained in the handle housing where the clinician cannot readily access it and move it between a safety position preventing actuation of the firing trigger 1120 and a firing position wherein the firing trigger 1120 may be fired. As the clinician depresses the closure trigger 1052, the safety button 1122 and the firing trigger 1120 pivot down wherein they can then be manipulated by the clinician.

As indicated above, in at least one form, the longitudinally movable drive member 1110 has a rack of teeth 1112 formed thereon for meshing engagement with a corresponding drive gear 1114 of the gear reducer assembly 1108. At least one form may also include a manually-actuatable "bailout" assembly **1130** that is configured to enable the clinician to manually retract the longitudinally movable drive member **1110** should the motor become disabled. The bailout assembly **1130** may include a lever or bailout handle assembly **1132** that is configured to be manually pivoted into ratcheting engagement with the teeth **1112** in the drive member **1110**. Thus, the clinician can manually retract the drive member **1110** by using the bailout handle assembly **1132** to ratchet the drive member in the proximal direction "P". U.S. Pat. No. 8,608,045 discloses bailout arrangements and other components, arrangements and systems that may also be employed with the various instruments disclosed herein. U.S. patent application Ser. No. 12/249,117, entitled POWERED SURGICAL CUTTING AND STAPLING APPARATUS WITH MANUALLY RETRACTABLE FIRING SYSTEM, which issued on Dec. 17, 2013 as U.S. Pat. No. 8,608,045, is incorporated by reference in its entirety.

FIGS. **34** and **37** illustrate one form of interchangeable shaft assembly **1200** that has, for example, a surgical end effector **1300** operably attached thereto. The end effector **1300** as illustrated in those Figures may be configured to cut and staple tissue in the various manners disclosed herein. For example, the end effector **1300** may include a channel **1302** that is configured to support a surgical staple cartridge **1304**. The staple cartridge **1304** may comprise a removable staple cartridge **1304** such that it may be replaced when spent. However, the staple cartridge in other arrangements may be configured such that once installed within the channel **1302**, it is not intended to be removed therefrom. The channel **1032** and staple cartridge **1304** may be collectively referred to as a "first jaw portion" of the end effector **1300**. In various forms, the end effector **1300** may have a "second jaw portion", in the form of an anvil **1310**, that is movably or pivotally supported on the channel **1302** in the various manners discussed herein.

The interchangeable shaft assembly **1200** may further include a shaft **1210** that includes a shaft frame **1212** that is coupled to a shaft attachment module or shaft attachment portion **1220**. In at least one form, a proximal end **1214** of the shaft frame **1212** may extend through a hollow collar portion **1222** formed on the shaft attachment module **1220** and be rotatably attached thereto. For example, an annular groove **1216** may be provided in the proximal end **1214** of the shaft frame **1212** for engagement with a U-shaped retainer **1226** that extends through a slot **1224** in the shaft attachment module **1220**. Such arrangement enables the shaft frame **1212** to be rotated relative to the shaft attachment module **1220**.

The shaft assembly **1200** may further comprise a hollow outer sleeve or closure tube **1250** through which the shaft frame **1212** extends. The outer sleeve **1250** may also be referred to herein as a "first shaft" and/or a "first shaft assembly". The outer sleeve **1250** has a proximal end **1252** that is adapted to be rotatably coupled to a closure tube attachment yoke **1260**. As can be seen in FIG. **37**, the proximal end **1252** of the outer sleeve **1250** is configured to be received within a cradle **1262** in the closure tube attachment yoke **1260**. A U-shaped connector **1266** extends through a slot **1264** in the closure tube attachment yoke **1260** to be received in an annular groove **1254** in the proximal end **1252** of the outer sleeve **1250**. Such arrangement serves to rotatably couple the outer sleeve **1250** to the closure tube attachment yoke **1260** such that the outer sleeve **1250** may rotate relative thereto.

As can be seen in FIGS. **38** and **39**, the proximal end **1214** of the shaft frame **1214** protrudes proximally out of the proximal end **1252** of the outer sleeve **1250** and is rotatably coupled to the shaft attachment module **1220** by the U-shaped retainer **1226** (shown in FIG. **38**). The closure tube attachment yoke **1260** is configured to be slidably received within a passage **1268** in the shaft attachment module **1220**. Such arrangement permits the outer sleeve **1250** to be axially moved in the proximal direction "P" and the distal direction "D" on the shaft frame **1212** relative to the shaft attachment module **1220** as will be discussed in further detail below.

In at least one form, the interchangeable shaft assembly **1200** may further include an articulation joint **1350**. Other interchangeable shaft assemblies, however, may not be capable of articulation. As can be seen in FIG. **37**, for example, the articulation joint **1350** includes a double pivot closure sleeve assembly **1352**. According to various forms, the double pivot closure sleeve assembly **1352** includes a shaft closure sleeve assembly **1354** having upper and lower distally projecting tangs **1356**, **1358**. An end effector closure sleeve assembly **1354** includes a horseshoe aperture **1360** and a tab **1362** for engaging an opening tab on the anvil **1310** in the manner described above. As described above, the horseshoe aperture **1360** and tab **1362** engage the anvil tab when the anvil **1310** is opened. An upper double pivot link **1364** includes upwardly projecting distal and proximal pivot pins that engage respectively an upper distal pin hole in the upper proximally projecting tang **1356** and an upper proximal pin hole in an upper distally projecting tang **1256** on the outer sleeve **1250**. A lower double pivot link **1366** includes downwardly projecting distal and proximal pivot pins that engage respectively a lower distal pin hole in the lower proximally projecting tang **1358** and a lower proximal pin hole in the lower distally projecting tang **1258**.

In use, the closure sleeve assembly **1354** is translated distally (direction "D") to close the anvil **1310**, for example, in response to the actuation of the closure trigger **1052**. The anvil **1310** is closed by distally translating the outer sleeve **1250**, and thus the shaft closure sleeve assembly **1354**, causing it to strike a proximal surface on the anvil **1310** in the manner described above. As was also described above, the anvil **1310** is opened by proximally translating the outer sleeve **1250** and the shaft closure sleeve assembly **1354**, causing tab **1362** and the horseshoe aperture **1360** to contact and push against the anvil tab to lift the anvil **1310**. In the anvil-open position, the shaft closure sleeve assembly **1352** is moved to its proximal position.

In at least one form, the interchangeable shaft assembly **1200** further includes a firing member **1270** that is supported for axial travel within the shaft frame **1212**. The firing member **1270** includes an intermediate firing shaft portion **1272** that is configured for attachment to a distal cutting portion **1280**. The firing member **1270** may also be referred to herein as a "second shaft" and/or a "second shaft assembly". As can be seen in FIG. **37**, the intermediate firing shaft portion **1272** may include a longitudinal slot **1274** in the distal end thereof which can be configured to receive the proximal end **1282** of the distal cutting portion **1280**. The longitudinal slot **1274** and the proximal end **1282** can be sized and configured to permit relative movement therebetween and can comprise a slip joint **1276**. The slip joint **1276** can permit the intermediate firing shaft portion **1272** of the firing drive **1270** to be moved to articulate the end effector **1300** without moving, or at least substantially moving, the distal cutting portion **1280**. Once the end effector **1300** has been suitably oriented, the intermediate firing shaft portion **1272** can be advanced distally until a proximal sidewall of the longitudinal slot **1272** comes into contact with the proximal end **1282** in order to advance the distal cutting portion **1280** and fire the staple cartridge positioned within the channel **1302**, as described herein. As can be further seen in FIG. **37**, the shaft frame **1212** has an elongate opening or window **1213** therein to facilitate assembly and insertion of the intermediate firing shaft portion **1272** into the shaft frame **1212**. Once the intermediate firing shaft portion **1272** has been inserted therein, a top frame segment **1215** may be engaged with the shaft frame **1212** to enclose the intermediate firing shaft portion **1272** and distal cutting portion **1280** therein. The reader will also note that the articulation joint **1350** can further include a guide **1368** which can be configured to receive the distal cutting portion **1280** of the firing member **1270** therein and guide the distal cutting portion **1280** as it is advanced distally and/or retracted proximally within and/or relative to the articulation joint **1350**.

As can be seen in FIG. **37**, the shaft attachment module **1220** may further include a latch actuator assembly **1230** that may be removably attached to the shaft attachment module by cap screws (not shown) or other suitable fasteners. The latch actuator assembly **1230** is configured to cooperate with a lock yoke **1240** that is pivotally coupled to the shaft attachment module **1220** for selective pivotal travel relative thereto. See FIG. **41**. Referring to FIG. **39**, the lock yoke **1240** may include two proximally protruding lock lugs **1242** (FIG. **37**) that are configured for releasable engagement with corresponding lock detents or grooves **1086** formed in a frame attachment module portion **1084** of the frame **1080** as will be discussed in further detail below. The lock yoke **1240** is substantially U-shaped and is installed over the latch actuator assembly **1230** after the latch actuator assembly **1230** has been coupled to the shaft attachment module **1220**. The latch actuator assembly **1230** may have an arcuate body portion **1234** that provides sufficient clearance for the lock yoke **1240** to pivot relative thereto between latched and unlatched positions.

In various forms, the lock yoke **1240** is biased in the proximal direction by spring or biasing member (not shown). Stated another way, the lock yoke **1240** is biased into the latched position (FIG. **40**) and can be pivoted to an unlatched position (FIG. **41**) by a latch button **1236** that is movably supported on the latch actuator assembly **1230**. In at least one arrangement, for example, the latch button **1236** is slidably retained within a latch housing portion **1235** and is biased in the proximal direction "P" by a latch spring or biasing member (not shown). As will be discussed in further detail below, the latch button **1236** has a distally protruding release lug **1237** that is designed to engage the lock yoke **1240** and pivot it from the latched position to the unlatched position shown in FIG. **41** upon actuation of the latch button **1236**.

The interchangeable shaft assembly **1200** may further include a nozzle assembly **1290** that is rotatably supported on the shaft attachment module **1220**. In at least one form, for example, the nozzle assembly **1290** can be comprised of two nozzle halves, or portions, **1292**, **1294** that may be interconnected by screws, snap features, adhesive, etc. When mounted on the shaft attachment module **1220**, the nozzle assembly **1290** may interface with the outer sleeve **1250** and shaft frame **1212** to enable the clinician to selectively rotate the shaft **1210** relative to the shaft attachment module **1220** about a shaft axis SA-SA which may be defined for example, the axis of the firing member assembly **1270**. In particular, a portion of the nozzle assembly **1290** may extend through a window **1253** in the outer sleeve to engage a notch **1218** in the shaft frame **1212**. See FIG. **37**. Thus, rotation of the nozzle assembly **1290** will result in rotation of the shaft frame **1212** and outer sleeve **1250** about axis A-A relative to the shaft attachment module **1220**.

Referring now to FIGS. **42** and **43**, the reader will observe that the frame attachment module portion **1084** of the frame **1080** is formed with two inwardly facing dovetail receiving slots **1088**. Each dovetail receiving slot **1088** may be tapered or, stated another way, be somewhat V-shaped. See, for example, FIGS. **36** and **38** (only one of the slots **1088** is shown). The dovetail receiving slots **1088** are configured to releasably receive corresponding tapered attachment or lug portions **1229** of a proximally-extending connector portion **1228** of the shaft attachment module **1220**. As can be further seen in FIGS. **37-39**, a shaft attachment lug **1278** is formed on the proximal end **1277** of the intermediate firing shaft **1272**. As will be discussed in further detail below, when the interchangeable shaft assembly **1200** is coupled to the handle **1042**, the shaft attachment lug **1278** is received in a firing shaft attachment cradle **1113** formed in the distal end **1111** of the longitudinal drive member **1110**. Also, the closure tube attachment yoke **1260** includes a proximally-extending yoke portion **1265** that includes two capture slots **1267** that open downwardly to capture the attachment lugs **1066** on the closure attachment bar **1064**.

Attachment of the interchangeable shaft assembly **1220** to the handle **1042** will now be described with reference to FIGS. **44-48**. In various forms, the frame **1080** or at least one of the drive systems define an actuation axis AA-AA. For example, the actuation axis AA-AA may be defined by the axis of the longitudinally-movable drive member **1110**. As such, when the intermediate firing shaft **1272** is operably coupled to the longitudinally movable drive member **1110**, the actuation axis AA-AA is coaxial with the shaft axis SA-SA as shown in FIG. **48**.

To commence the coupling process, the clinician may position the shaft attachment module **1220** of the interchangeable shaft assembly **1200** above or adjacent to the frame attachment module portion **1084** of the frame **1080** such that the attachment lugs **1229** formed on the connector portion **1228** of the shaft attachment module **1220** are aligned with the dovetail slots **1088** in the attachment module portion **1084** as shown in FIG. **45**. The clinician may then move the shaft attachment module **1220** along an installation axis IA-IA that is substantially transverse to the actuation axis AA-AA. Stated another way, the shaft attachment module **1220** is moved in an installation direction "ID" that is substantially transverse to the actuation axis AA-AA until the attachment lugs **1229** of the connector portion **1228** are seated in "operable engagement" with the corresponding dovetail receiving slots **1088**. See FIGS. **44** and **46**. FIG. **47** illustrates the position of the shaft attachment module **1220** prior to the shaft attachment lug **1278** on the intermediate firing shaft **1272** entering the cradle **1113** in the longitudinally movable drive member **1110** and the attachment lugs **1066** on the closure attachment bar **1064** entering the corresponding slots **1267** in the yoke portion **1265** of the closure tube attachment yoke **1260**. FIG. **48** illustrates the position of the shaft attachment module **1220** after the attachment process has been completed. As can be seen in that Figure, the lugs **1066** (only one is shown) are seated in operable engagement in their respective slots **1267** in the yoke portion **1265** of the closure tube attachment yoke **1260**. As used herein, the term "operable engagement" in the context of two components means that the two components are sufficiently engaged with each other so that upon application of an actuation motion thereto, the components may carry out their intended action, function and/or procedure.

As discussed above, referring again to FIGS. **44-49**, at least five systems of the interchangeable shaft assembly **1200** can be operably coupled with at least five corresponding systems of the handle **1042**. A first system can comprise a frame system which couples and/or aligns the frame of the shaft assembly **1200** with the frame of the handle **1042**. As outlined above, the connector portion **1228** of the shaft assembly **1200** can be engaged with the attachment module portion **1084** of the handle frame **1080**. A second system can comprise a closure drive system which can operably connect the closure trigger **1052** of the handle **1042** and the closure tube **1250** and the anvil **1310** of the shaft assembly **1200**. As outlined above, the closure tube attachment yoke **1260** of the shaft assembly **1200** can be engaged with the attachment lugs **1066** of the handle **1042**. A third system can comprise a firing drive system which can operably connect the firing trigger **1120** of the handle **1042** with the intermediate firing shaft **1272** of the shaft assembly **1200**. As outlined above, the shaft attachment lug **1278** can be operably connected with the cradle **1113** of the longitudinal drive member **1110**. A fourth system can comprise an electrical system which can, one, signal to a controller in the handle **1042**, such as microcontroller **7004**, for example, that a shaft assembly, such as shaft assembly **1200**, for example, has been operably engaged with the handle **1042** and/or, two, conduct power and/or communication signals between the shaft assembly **1200** and the handle **1042**. For instance, the shaft assembly **1200** can include six electrical contacts and the electrical connector **4000** can also include six electrical contacts wherein each electrical contact on the shaft assembly **1200** can be paired and mated with an electrical contact on the electrical connector **4000** when the shaft assembly **1200** is assembled to the handle **1042**. The shaft assembly **1200** can also include a latch **1236** which can be part of a fifth system, such as a lock system, which can releasably lock the shaft assembly **1200** to the handle **1042**. In various circumstances, the latch **1236** can close a circuit in the handle **1042**, for example, when the latch **1236** is engaged with the handle **1042**.

Further to the above, the frame system, the closure drive system, the firing drive system, and the electrical system of the shaft assembly **1200** can be assembled to the corresponding systems of the handle **1042** in a transverse direction, i.e., along axis IA-IA, for example. In various circumstances, the frame system, the closure drive system, and the firing drive system of the shaft assembly **1200** can be simultaneously coupled to the corresponding systems of the handle **1042**. In certain circumstances, two of the frame system, the closure drive system, and the firing drive system of the shaft assembly **1200** can be simultaneously coupled to the corresponding systems of the handle **1042**. In at least one circumstance, the frame system can be at least initially coupled before the closure drive system and the firing drive system are coupled. In such circumstances, the frame system can be configured to align the corresponding components of the closure drive system and the firing drive system before they are coupled as outlined above. In various circumstances, the electrical system portions of the housing assembly **1200** and the handle **1042** can be configured to be coupled at the same time that the frame system, the closure drive system, and/or the firing drive system are finally, or fully, seated. In certain circumstances, the electrical system portions of the housing assembly **1200** and the handle **1042** can be configured to be coupled before the frame system, the closure drive system, and/or the firing drive system are finally, or fully, seated. In some circumstances, the electrical system portions of the housing assembly **1200** and the handle **1042** can be configured to be coupled after the frame system has been at least partially coupled, but before the closure drive system and/or the firing drive system are have been coupled. In various circumstances, the locking system can be configured such that it is the last system to be engaged, i.e., after the frame system, the closure drive system, the firing drive system, and the electrical system have all been engaged.

As outlined above, referring again to FIGS. **44-49**, the electrical connector **4000** of the handle **1042** can comprise a plurality of electrical contacts. Turning now to FIG. **197**, the electrical connector **4000** can comprise a first contact **4001***a*, a second contact **4001***b*, a third contact **4001***c*, a fourth contact **4001***d*, a fifth contact **4001***e*, and a sixth contact **4001***f*, for example. While the illustrated embodiment utilizes six contacts, other embodiments are envisioned which may utilize more than six contacts or less than six contacts. As illustrated in FIG. **197**, the first contact **4001***a* can be in electrical communication with a transistor **4008**, contacts **4001***b*-**4001***e* can be in electrical communication with a microcontroller **7004**, and the sixth contact **4001***f* can be in electrical communication with a ground. Microcontroller **7004** is discussed in greater detail further below. In certain circumstances, one or more of the electrical contacts **4001***b*-**4001***e* may be in electrical communication with one or more output channels of the microcontroller **7004** and can be energized, or have a voltage potential applied thereto, when the handle **1042** is in a powered state. In some circumstances, one or more of the electrical contacts **4001***b*-**4001***e* may be in electrical communication with one or more input channels of the microcontroller **7004** and, when the handle **1042** is in a powered state, the microcontroller **7004** can be configured to detect when a voltage potential is applied to such electrical contacts. When a shaft assembly, such as shaft assembly **1200**, for example, is assembled to the handle **1042**, the electrical contacts **4001***a*-**4001***f* may not communicate with each other. When a shaft assembly is not assembled to the handle **1042**, however, the electrical contacts **4001***a*-**4001***f* of the electrical connector **4000** may be exposed and, in some circumstances, one or more of the contacts **4001***a*-**4001***f* may be accidentally placed in electrical communication with each other. Such circumstances can arise when one or more of the contacts **4001***a*-**4001***f* come into contact with an electrically conductive material, for example. When this occurs, the microcontroller **7004** can receive an erroneous input and/or the shaft assembly **1200** can receive an erroneous output, for example. To address this issue, in various circumstances, the handle **1042** may be unpowered when a shaft assembly, such as shaft assembly **1200**, for example, is not attached to the handle **1042**. In other circumstances, the handle **1042** can be powered when a shaft assembly, such as shaft assembly **1200**, for example, is not attached thereto. In such circumstances, the microcontroller **7004** can be configured to ignore inputs, or voltage potentials, applied to the contacts in electrical communication with the microcontroller **7004**, i.e., contacts **4001***b*-**4001***e*, for example, until a shaft assembly is attached to the handle **1042**. Even though the microcontroller **7004** may be supplied with power to operate other functionalities of the handle **1042** in such circumstances, the handle **1042** may be in a powered-down state. In a way, the electrical connector **4000** may be in a powered-down state as voltage potentials applied to the electrical contacts **4001***b*-**4001***e* may not affect the operation of the handle **1042**. The reader will appreciate that, even though contacts **4001***b*-**4001***e* may be in a powered-down state, the electrical contacts **4001***a* and **4001***f*, which are not in electrical communication with the microcontroller **7004**, may or may not be in a powered-down state. For instance, sixth contact **4001***f* may remain in electrical communication with a ground regardless of whether the handle **1042** is in a powered-up or a powered-down state. Furthermore, the transistor **4008**, and/or any other suitable arrangement of transistors, such as transistor **4010**, for example, and/or switches may be configured to control the supply of power from a power source **4004**, such as a battery **1104** within the handle **1042**, for example, to the first electrical contact **4001***a* regardless of whether the handle **1042** is in a powered-up or a powered-down state as outlined above. In various circumstances, the latch **1236** of the shaft assembly **1200**, for example, can be configured to change the state of the transistor **4008** when the latch **1236** is engaged with the handle **1042**. In various circumstances, as described elsewhere herein, the latch **1236** can be configured to close a circuit when it engages the handle **1042** and, as a result, affect the state of the transistor **4008**. In certain circumstances, further to the below, a Hall effect sensor **4002** can be configured to switch the state of transistor **4010** which, as a result, can switch the state of transistor **4008** and ultimately supply power from power source **4004** to first contact **4001***a*. In this way, further to the above, both the power circuits and the signal circuits to the connector **4000** can be powered down when a shaft assembly is not installed to the handle **1042** and powered up when a shaft assembly is installed to the handle **1042**.

In various circumstances, referring again to FIG. **197**, the handle **1042** can include the Hall effect sensor **4002**, for example, which can be configured to detect a detectable element, such as a magnetic element, for example, on a shaft assembly, such as shaft assembly **1200**, for example, when the shaft assembly is coupled to the handle **1042**. The Hall effect sensor **4002** can be powered by a power source **4006**, such as a battery, for example, which can, in effect, amplify the detection signal of the Hall effect sensor **4002** and communicate with an input channel of the microcontroller **7004** via the circuit illustrated in FIG. **197**. Once the microcontroller **7004** has a received an input indicating that a shaft assembly has been at least partially coupled to the handle **1042**, and that, as a result, the electrical contacts **4001***a*-**4001***f* are no longer exposed, the microcontroller **7004** can enter into its normal, or powered-up, operating state. In such an operating state, the microcontroller **7004** will evaluate the signals transmitted to one or more of the contacts **4001***b*-**4001***e* from the shaft assembly and/or transmit signals to the shaft assembly through one or more of the contacts **4001***b*-**4001***e* in normal use thereof. In various circumstances, the shaft assembly **1200** may have to be fully seated before the Hall effect sensor **4002** can detect the magnetic element. While a Hall effect sensor **4002** can be utilized to detect the presence of the shaft assembly **1200**, any suitable system of sensors and/or switches can be utilized to detect whether a shaft assembly has been assembled to the handle **1042**, for example. In this way, further to the above, both the power circuits and the signal circuits to the connector **4000** can be powered down when a shaft assembly is not installed to the handle **1042** and powered up when a shaft assembly is installed to the handle **1042**.

In various embodiments, any number of magnetic sensing elements may be employed to detect whether a shaft assembly has been assembled to the handle **1042**, for example. For example, the technologies used for magnetic field sensing include search coil, fluxgate, optically pumped, nuclear precession, SQUID, Hall-effect, anisotropic magnetoresistance, giant magnetoresistance, magnetic tunnel junctions, giant magnetoimpedance, magnetostrictive/piezoelectric composites, magnetodiode, magnetotransistor, fiber optic, magnetooptic, and microelectromechanical systems-based magnetic sensors, among others.

After the interchangeable shaft assembly **1200** has been operably coupled to the handle **1042**, actuation of the closure trigger **1052** will result in the distal axial advancement of the outer sleeve **1250** and the shaft closure sleeve assembly **1354** coupled thereto to actuate the anvil **1310** in the various manners disclosed herein. As can also be seen in FIG. **48**, the firing member **1270** in the interchangeable shaft assembly **1200** is coupled to the longitudinally movable drive member **1110** in the handle **1042**. More specifically, the shaft attachment lug **1278** formed on the proximal end **1277** of the intermediate firing shaft **1272** is receive within the firing shaft attachment cradle **1113** formed in the distal end **1111** of the longitudinally movable drive member **1110**. Thus, actuation of the firing trigger **1120** which results in powering of the motor **1102** to axially advance the longitudinally movable drive member **1110** will also cause the firing member **1270** to axially move within the shaft frame **1212**. Such action will cause the advancement of the distal cutting portion **1280** through the tissue clamped in the end effector **1300** in the various manners disclosed herein. Although not observable in FIG. **48**, those of ordinary skill in the art will also understand that when in the coupled position depicted in that Figure, the attachment lug portions **1229** of the shaft attachment module **1220** are seated within their respective dovetail receiving slots **1088** in the attachment module portion **1084** of the frame **1080**. Thus, the shaft attachment module **1220** is coupled to the frame **1080**. In addition, although not shown in FIG. **48** (but which can be seen in FIG. **40**), when the shaft attachment module **1220** has been coupled to the frame **1080**, the lock lugs **1242** on the lock yoke **1240** are seated within their respective lock grooves **1086** (only one is shown in FIG. **40**) in the attachment module portion **1084** of the frame **1080** to releasably retain the shaft attachment module **1220** in coupled operable engagement with the frame **1080**.

To detach the interchangeable shaft assembly **1220** from the frame **1080**, the clinician pushes the latch button **1236** in the distal direction "D" to cause the lock yoke **1240** to pivot as shown in FIG. **41**. Such pivotal movement of the lock yoke **1240** causes the lock lugs **1242** thereon to move out of retaining engagement with the lock grooves **1086**. The clinician may then move the shaft attachment module **1220** away from the handle in a disconnecting direction "DD" as shown in FIG. **49**.

Those of ordinary skill in the art will understand that the shaft attachment module **1220** may also be held stationary and the handle **1042** moved along the installation axis IA-IA that is substantially transverse to the shaft axis SA-SA to bring the lugs **1229** on the connector portion **1228** into seating engagement with the dovetail slots **1088**. It will be further understood that the shaft attachment module **1220** and the handle **1042** may be simultaneously moved toward each other along the installation axis IA-IA that is substantially transverse to the shaft axis SA-SA and the actuation axis AA-AA.

As used herein, the phrase, "substantially transverse to the actuation axis and/or to the shaft axis" refers to a direction that is nearly perpendicular to the actuation axis and/or shaft axis. It will be appreciated, however, that directions that deviate some from perpendicular to the actuation axis and/or the shaft axis are also substantially transverse to those axes.

FIGS. **50-57** illustrate another arrangement for coupling an interchangeable shaft assembly **1600** to a frame **1480** of a handle (not shown) that otherwise functions like the handle **1042** discussed in detail herein. Thus, only those details necessary to understand the unique and novel coupling features of the shaft assembly **1600** will be discussed in further detail. Those of ordinary skill in the art will understand, however, that the frame may be supported within a housing of a robotic system that otherwise operably supports or houses a plurality of drive systems. In other arrangements, the frame may comprise portion of a robotic system for operably affixing interchangeable shaft assemblies thereto.

In at least one form, the shaft assembly **1600** includes a shaft **1610** that may include all of the other components of shaft **1210** described above and may have an end effector (not shown) of the type described above operably attached thereto.

Turning to FIG. **57**, in the illustrated arrangement, the shaft assembly **1600** includes a closure tube attachment yoke **1660** that may be rotatably coupled to an outer sleeve **1650** in the manner in which the closure tube yoke assembly **1260** was rotatably coupled to the outer sleeve **1250**.

In various forms, the shaft assembly **1600** includes a shaft attachment module or shaft attachment portion **1620** that has an open bottom **1621**. The shaft **1610** is coupled to the shaft attachment module **1620** by inserting the proximal end of the shaft **1610** through an opening **1622** in the shaft attachment module **1620**. The closure tube attachment yoke **1660** may be inserted into the shaft attachment module **1620** through the open bottom portion **1621** such that the proximal end **1652** of the outer sleeve **1650** is received within the cradle **1662** in the closure tube attachment yoke **1660**. In the manner discussed above, a U-shaped connector **1666** is passed through a slot **1624** in the shaft attachment module **1620** to engage an annular groove **1654** in the proximal end **1652** of the outer sleeve **1250** and slots **1664** in the closure tube attachment yoke **1660** to affix the outer sleeve **1650** to the closure tube attachment yoke **1660**. As was discussed above, such arrangement enables the outer sleeve **1650** to rotate relative to the shaft attachment module **1620**.

In at least one form, the closure tube attachment yoke **1660** is configured to be supported within the shaft attachment module **1620** such that the closure tube yoke attachment yoke **1660** may move axially therein in the distal and proximal directions. In at least one form, a closure spring **1625** is provided within the shaft attachment module to bias the closure tube yoke assembly **1660** in the proximal direction "P". See FIG. **57**. As with the above described shaft assembly **1210**, the proximal end **1614** of the shaft frame **1612** protrudes proximally out of the proximal end **1652** of the outer sleeve **1650**. As can be seen in FIG. **57** a retaining collar **1617** may be formed on the proximal end **1614** of the shaft frame **1612**. A U-shaped retainer member **1627** is inserted through a lateral slot **1633** in the shaft attachment module **1620** to retain the proximal end **1652** of the outer sleeve in that axial position while enabling the outer sleeve **1650** to rotate relative to the shaft attachment module **1620**. Such arrangement permits the clinician to rotate the shaft **1610** about the shaft axis SA-SA relative to the shaft attachment module **1620**. Those of ordinary skill in the art will appreciate that the shaft **1610** may be rotated by the same or similar nozzle arrangement that was described above. For example, the nozzle portions (not shown) may be assembled around the outer sleeve **1650** and engage the notch **1618** in the shaft frame **1612** through the window **1653** in the outer sleeve **1650**. See FIG. **53**.

In at least one form, the frame **1480** has a frame attachment module or frame attachment portion **1484** formed thereon or attached thereto. The frame attachment module **1484** may be formed with opposed dovetail receiving slots **1488**. Each dovetail receiving slot **1488** may be tapered or, stated another way, be somewhat V-shaped. The slots **1488** are configured to releasably receive corresponding portion of a dovetail connector **1629** protruding from a proximal end of the shaft attachment module **1620**. As can be seen in FIG. **52**, the proximal end **1677** of the intermediate firing shaft **1672** protrudes proximally out of the shaft attachment module **1620** and has a shaft attachment lug **1678** formed thereon. The proximal end **1677** of the intermediate firing shaft **1672** may extend through the space between the end walls **1485** of the frame attachment module **1484** to enable the shaft attachment lug **1678** formed thereon to be received in a firing shaft attachment cradle **1513** formed in the distal end **1511** of the longitudinally moveable drive member **1510**. See FIG. **57**. When the interchangeable shaft assembly **1600** is coupled to the handle or housing or frame of the surgical instrument, device, robotic system, etc., the shaft attachment lug **1678** is received in a firing shaft attachment cradle **1513** formed in the distal end **1511** of the longitudinally movable drive member **1510**.

As can also be seen in FIGS. **52-55**, the frame attachment module **1484** may have a distally protruding bottom member **1490** that is adapted to enclose at least a portion of the open bottom **1621** of the shaft attachment module **1620** when the shaft attachment module **1620** is operably coupled to the frame attachment module **1484**. In one form, the closure tube attachment yoke **1660** has a pair of proximally extending, spaced yoke arms **1661** protruding therefrom. A transverse yoke attachment pin **1663** may extend therebetween. See FIG. **57**. When the shaft attachment module **1620** is brought into operable engagement with the frame attachment module **1484**, the yoke attachment pin **1663** is configured to be hookingly engaged by a hook **1469** formed on a closure link **1467** of the closure drive system **1450**. The closure drive system **1450** may be similar to the closure drive system **1050** described above and include a closure trigger **1452** and a closure linkage assembly **1460**. The closure linkage assembly **1460** may include a closure link **1462** that is pivotally coupled to the closure attachment bar **1464**. The closure attachment bar **1464** is pivotally coupled to the closure link **1467**. See FIG. **54**.

A method for coupling the shaft assembly **1600** to the frame **1480** may be understood from reference to FIGS. **53** and **54**. As with other arrangements disclosed herein, the shaft assembly **1600** may define a shaft axis SA-SA and the frame **1480** may define an actuation axis AA-AA. For example, the shaft axis SA-SA may be defined by the firing member **1670** and the actuation axis AA-AA may be defined by the longitudinally movable drive member **1510**. To commence the coupling process, the clinician may position the shaft attachment module **1620** of the interchangeable shaft assembly **1600** above or adjacent to the frame attachment module **1484** of the frame **1480** such that the dovetail connector **1629** of the shaft attachment module **1620** is aligned with the dovetail slots **1488** in the frame attachment module **1484** as shown in FIG. **53**. The clinician may then move the shaft attachment module **1620** along an installation axis IA-IA that is substantially transverse to the actuation axis AA-AA. Stated another way, the shaft attachment module **1620** is moved in an installation direction "ID" that is substantially transverse to the actuation axis AA-AA until the dovetail connector **1629** is seated in the dovetail slots **1488** in the frame module **1484**. See FIGS. **55-57**. When the shaft attachment module **1620** has been operably engaged with the frame attachment module **1484**, the closure tube attachment yoke **1665** will be operably engaged with the closure drive system **1450** and actuation of the closure trigger **1452** will result in the distal axial advancement of the outer sleeve **1650** and the shaft closure tube assembly coupled thereto to actuate the anvil in the various manners disclosed herein. Likewise, the firing member **1270** will be operably engaged with the longitudinally movable drive member **1510**. See FIG. **57**. Thus, actuation of the motor (not shown) of the firing drive system **1500** will result in the axial advancement of the longitudinally movable drive member **1510** as well as the firing member **1670**. Such action will cause the advancement of the distal cutting portion of the firing member (not shown) through the tissue clamped in the end effector in the various manners disclosed herein.

FIGS. **58-62** illustrate another arrangement for coupling an interchangeable shaft assembly **1900** to a frame **1780** of a handle (not shown) that otherwise functions like the handle

1042 discussed in detail herein. Thus, only those details necessary to understand the unique and novel coupling features of the shaft assembly **1900** will be discussed in further detail. Those of ordinary skill in the art will understand, however, that the frame may be supported within a housing or other portion of a robotic system that otherwise operably supports or houses a plurality of drive systems. In other arrangements, the frame may comprise portion of a robotic system for operably affixing interchangeable shaft assemblies thereto.

In at least one form, the shaft assembly **1900** includes a shaft **1910** that may include all of the other components of shaft **1210** described above and may have an end effector of the type described above, for example, (not shown) operably attached thereto. Turning to FIG. **62**, in the illustrated arrangement, the shaft assembly **1900** includes a closure tube attachment yoke **1960** that may be rotatably coupled to an outer sleeve **1950** in the manner in which the closure tube yoke assembly **1260** was rotatably coupled to the outer sleeve **1250**.

In various forms, the shaft assembly **1900** may include a shaft attachment module or shaft attachment portion **1920** that has an open bottom **1921**. The shaft **1910** is coupled to the shaft attachment module **1920** by inserting the proximal end of the shaft **1910** through an opening **1922** in the shaft attachment module **1920**. The closure tube attachment yoke **1960** may be inserted into the shaft attachment module **1920** through the open bottom portion **1921** such that the proximal end **1952** of the outer sleeve **1950** is received within the cradle **1962** in the closure tube attachment yoke **1660**. In the manner discussed above, a U-shaped connector **1966** engages an annular groove (not shown) in the proximal end **1952** of the outer sleeve **1950** and slots **1964** in the closure tube attachment yoke **1960** to affix the outer sleeve **1950** to the closure tube attachment yoke **1960**. As was discussed above, such arrangement enables the outer sleeve **1950** to rotate relative to the shaft attachment module **1920**.

In at least one form, the closure tube attachment yoke **1960** is configured to be supported within the shaft attachment module **1920** such that the closure tube yoke assembly **1960** may move axially therein in the distal ("D") and proximal ("P") directions. As with the above described shaft assembly **1210**, the proximal end of the shaft frame protrudes proximally out of the proximal end **1952** of the outer sleeve **1950**. As can be seen in FIG. **62**, a retaining collar **1917** may be formed on the proximal end of the shaft frame. A U-shaped retainer member **1927** may be employed to retain the proximal end of the shaft frame in that axial position while enabling the shaft frame to rotate relative to the shaft attachment module **1920**. Such arrangement permits the clinician to rotate the shaft **1910** about the shaft axis SA-SA relative to the shaft attachment module **1920**. A nozzle assembly **1990** may be employed in the various manners discussed herein to facilitate rotation of the shaft **1910** relative to the shaft attachment module **1920**.

The interchangeable shaft assembly **1900** may further include a nozzle assembly **1990** that is rotatably supported on the shaft attachment module **1920**. In at least one form, for example, the nozzle assembly **1990** can be comprised of two nozzle halves, or portions that may be interconnected by screws, snap features, adhesive, etc. When mounted on the shaft attachment module **1920**, the nozzle assembly **1990** may interface with a shaft rotation adapter **1995** that is configured to engage the outer sleeve **1950** and shaft frame **1912** to enable the clinician to selectively rotate the shaft **1910** relative to the shaft attachment module **1920** about a shaft axis SA-SA which may be defined for example, the axis of the firing member assembly. Thus, rotation of the nozzle assembly **1990** will result in rotation of the shaft frame and outer sleeve **1950** about axis A-A relative to the shaft attachment module **1920**.

In at least one form, the frame **1780** has a frame attachment module or frame attachment portion **1784** formed thereon or attached thereto. The frame attachment module **1784** may be formed with outwardly facing dovetail receiving slots **1788**. Each dovetail receiving slot **1788** may be tapered or, stated another way, be somewhat V-shaped. See FIG. **60**. The slots **1788** are configured to releasably operably engage corresponding inwardly-facing dovetail connector portions **1929** formed on the shaft attachment module **1920**. As can be seen in FIG. **60**, the proximal end **1977** of the intermediate firing shaft **1972** protrudes proximally out of the shaft attachment module **1920** and has a shaft attachment lug **1978** formed thereon. The shaft attachment lug **1978** is configured to be received in a firing shaft attachment cradle **1813** formed in the distal end **1811** of the longitudinally moveable drive member **1810**. See FIG. **62**. When the interchangeable shaft assembly **1900** is in operable engagement with the frame or housing of the surgical instrument, device, robotic system, etc., the shaft attachment lug **1978** is received in operable engagement in a firing shaft attachment cradle **1813** formed in the distal end **1811** of the longitudinal drive member **1810**.

In at least one form, the closure tube attachment yoke **1960** has a proximally extending yoke arm **1961** protruding therefrom that has a downwardly open hook **1963** formed thereon to engage an attachment lug **1766** formed on the closure attachment bar **1764** of the closure drive system **1750**. See FIG. **62**. When the shaft attachment module **1920** is brought into coupling engagement with the frame attachment module **1784**, the attachment lug **1766** is hookingly engaged by a hook **1963** formed on the closure tube yoke arm **1961**. The closure drive system **1750** may be similar to the closure drive system **1050** described above and include a closure trigger **1752** and a closure linkage assembly **1760**. The closure linkage assembly **1760** may include a closure link **1762** that is pivotally coupled to the closure attachment bar **1764**. See FIG. **62**. Actuation of the closure trigger **1752** will result in the axial movement of the closure attachment bar **1764** in the distal direction "D".

As with other arrangements disclosed herein, the shaft assembly **1900** may define a shaft axis SA-SA and the frame **1780** may define an actuation axis AA-AA. For example, the shaft axis SA-SA may be defined by the firing member **1970** and the actuation axis AA-AA may be defined by the longitudinally movable drive member **1810** operably supported by the frame **1780**. To commence the coupling process, the clinician may position the shaft attachment module **1920** of the interchangeable shaft assembly **1900** above or adjacent to the frame attachment module **1784** of the frame **1780** such that the dovetail connector portions **1929** of the shaft attachment module **1920** are each aligned with their corresponding dovetail slot **1788** in the frame attachment module **1784**. The clinician may then move the shaft attachment module **1920** along an installation axis that is substantially transverse to the actuation axis AA-AA. Stated another way, the shaft attachment module **1920** is moved in an installation direction that is substantially transverse to the actuation axis AA-AA until the dovetail connectors **1929** are seated in operable engagement in their corresponding dovetail slot **1788** in the frame module **1784**. When the shaft attachment module **1920** has been attached to the frame attachment module **1784**, the closure tube attachment yoke **1960** will be operably coupled to the closure drive system **1750** and actuation of the closure trigger **1752** will result in the distal axial advancement of the outer sleeve **1950** and the shaft closure tube assembly coupled thereto to actuate the anvil in the various manners disclosed herein. Likewise, the firing member will be coupled in operable engagement with the longitudinally movable drive member **1810**. See FIG. **62**. Thus, actuation of the motor (not shown) of the firing drive system **1800** will result in the axial advancement of the longitudinally movable drive member **1810** as well as the firing member **1970**. Such action will cause the advancement of the distal cutting portion of the firing member (not shown) through the tissue clamped in the end effector in the various manners disclosed herein.

FIGS. **63-66** illustrate another arrangement for coupling an interchangeable shaft assembly **2200** to a frame **2080** of a handle (not shown) that may function like the handle **1042** discussed in detail herein. Thus, only those details necessary to understand the unique and novel coupling features of the shaft assembly **2200** will be discussed in further detail. Those of ordinary skill in the art will understand, however, that the frame may be supported within a housing or other portion of a robotic system that otherwise operably supports or houses a plurality of drive systems. In other arrangements, the frame may comprise portion of a robotic system for operably affixing interchangeable shaft assemblies thereto.

In at least one form, the shaft assembly **2200** includes a shaft **2210** that may include all of the other components of shaft **1210** described above and may have an end effector (not shown) of the type described above operably attached thereto. The various constructions and operations of those features are described above. In the illustrated arrangement, the shaft assembly **2200** includes a closure tube attachment yoke **2260** that may be rotatably coupled to an outer sleeve **2250** in the manner in which the closure tube yoke attachment yoke **1260** was rotatably coupled to the outer sleeve **1250**. The shaft assembly **2200**, however, does not include a shaft attachment module as was described above.

As can be seen in FIGS. **63-65**, the frame **2080** may be formed in first frame part **2080**A and a second frame part **2080**B. In those applications wherein the frame **2080** is employed with a handle, the first and second frame parts **2080**A and **2080**B may each be associated with a handle housing portion. Thus, when the clinician desires to attach a different shaft assembly **2200**, the clinician may have to detach the handle housing portions from each other. In such arrangements for example, the housing portions may be connected together by removable fasteners or other arrangements that facilitate easy detachment of the housing portions. In other embodiments, the shaft assembly **2200** may be configured for a single use. In the illustrated arrangement, the first frame part **2080**A may operably support the various drive systems therein and the second frame part **2080**B may comprise a frame portion that retains the various components of the shaft assembly **2200** in operable engagement with their corresponding drive system components supported by the first frame part **2080**A.

In at least one form, the closure tube attachment yoke **2260** is configured to be supported within a passage **2081** in the frame **2080** such that the closure tube attachment yoke **2260** may move axially therein in the distal and proximal directions. As with the above described shaft assembly **1210**, the proximal end **2214** of the shaft frame **2212** protrudes proximally out of the proximal end of the **2252** of the outer sleeve **2250**. As can be seen in FIG. **63**, a retaining collar **2217** may be formed on the proximal end **2214** of the shaft frame **2212**. The retaining collar **2217** may be adapted to be rotatably received within an annular groove **2083** formed in the frame **2080**. Such arrangement serves to operable couple the shaft frame **2212** to the frame **2080** to prevent any relative axial movement between those components while enabling the shaft frame **2212** to rotate relative to the frame **2080**. This arrangement further permits the clinician to rotate the shaft **2210** about the shaft axis SA-SA relative to the frame. Those of ordinary skill in the art will appreciate that a nozzle arrangement that was described above may be employed to rotate the shaft **2210** about the shaft axis SA-SA relative to the frame **2080**. For example, the nozzle portions (not shown) may be assembled around the outer sleeve **2250** and engage the notch **2218** in the shaft frame **2212** through the window **2253** in the outer sleeve **2250**. See FIG. **64**.

As can be further seen in FIG. **64**, the proximal end **2277** of the intermediate firing shaft **2272** protrudes proximally out of the proximal end **2214** of the shaft frame **2212** and has a shaft attachment lug **2278** formed thereon. The firing shaft attachment cradle **2113** formed in the distal end **2111** of the longitudinally moveable drive member **2110** is formed to enable the firing shaft attachment lug **2278** to be loaded from the side. In an effort to aid the clinician in aligning the components of the shaft assembly **2220** and the first and second frame portions **2080**A and **2080**B during assembly, the second frame portion **2080**B may be provided with lugs **2090** that are configured to be received in corresponding holes or pockets **2091** formed in the first frame portion **2080**A and visa versa. In those single use applications wherein it is not desirable to be able to detach the shaft assembly **2200** from the frame **2080**, the pockets **2090** may be configured to permanently grip or engage the lugs **2090** inserted therein.

The first frame portion **2080**A and/or the longitudinally movable drive member **2110** which is movably supported by the first frame portion **2080**A may define an actuation axis A-A and the shaft assembly **2200** defines a shaft axis SA-SA. As can be seen in FIG. **64**, to commence the coupling process, the shaft assembly **2200** and the first frame portion **2080**A may be oriented relative to each other such that the shaft axis SA-SA is substantially parallel to the actuation axis AA-AA and such that the collar **2217** is laterally-aligned along an installation axis IA that is substantially transverse to the actuation axis with the annular groove **2083** and the shaft attachment lug **2278** is laterally aligned along another installation axis IA-IA that is also substantially transverse to the actuation axis AA-AA. The shaft assembly **2200** is then moved in an installation direction "ID" that is substantially transverse to the actuation axis AA-AA until the closure tube attachment yoke **2260** is seated with the portion of the passage **2081** formed in the first frame portion **2080**A, the collar **2217** is seated within the portion of the annular groove **2083** formed in the first frame portion **2080**A and the shaft attachment lug **2278** is seated in the shaft attachment cradle **2113** formed in the longitudinally movable drive member **2110**. In another arrangement, the shaft assembly **2200** and the first frame portion **2080**A may be brought together in a similar manner by holding the shaft assembly **2200** stationary and moving the first frame portion **2080**A toward the handle assembly **2200** until the above-mentioned component portions are operably seated together or the handle assembly **2200** and the first frame portion **2080**A may each be moved toward each other until they are seated together. Once the handle assembly **2200** has been operably seated within first frame portion **2080**A as shown in FIG. **63**, the second frame portion **2080**B may be joined with the first frame portion **2080**A by aligning the posts **2090** with their corresponding holes or pockets **2091** and joining the components together. The first and second frame portions **2080**A and **2080**B may be retained together by fasteners (e.g., screws, bolts, etc.), adhesive and/or snap features. In still other arrangements, the first frame portion **2080**A and the second frame portion **2080**B may be retained together in coupled engagement when their respective housing segments are joined together.

Once the first and second frame portions **2080**A, **2080***b* have been joined together as shown in FIGS. **65** and **66**, the clinician may then couple the closure drive system **2050** to the closure tube attachment yoke **2260**. The closure drive system **2050** may be similar to the closure drive system **1050** described above and include a closure trigger **2052** and a closure linkage assembly **2060**. The closure linkage assembly may include a closure link **2062** that is pivotally coupled to the closure attachment bar **2064**. In addition, another closure link **2067** is pivotally coupled to the closure attachment bar **2064**. The closure link **2067** may be configured for pivotal attachment to the arms **2261** of the closure tube attachment yoke **2260** by a pin **2269**. See FIG. **66**.

FIGS. **68-74** illustrate another arrangement for coupling an interchangeable shaft assembly **2500** to a frame **2380**. The frame **2380** may be employed with handle as described herein or may be employed in connection with a robotic system. In at least one form, the shaft assembly **2500** includes a shaft **2510** that may include all of the other components of shaft **1210** described above and may have an end effector (not shown) of the type described above operably attached thereto. The various constructions and operations of those features are described above. As can be seen in FIGS. **68-74**, the shaft assembly **2500** includes a shaft attachment module or shaft attachment portion **2520** that is configured to pivotally engage a frame attachment module portion **2384** of the frame **2380** as will be discussed in further detail below. The shaft attachment module **2520**, for example, may have a collar portion **2522** through which the proximal end of the shaft **2510** extends. The shaft attachment module **2520** cooperates with a frame attachment module portion **2384** of the frame **2380** to form a passage **2581** therein for movably supporting a closure tube attachment yoke **2560** therein. The closure tube yoke assembly **2560** may be supported on a portion of the shaft attachment module **2520** and is configured to be supported within the passage **2581** such that the closure tube yoke assembly **2560** may move axially therein in the distal and proximal directions. As with the above described shaft assemblies, the proximal end of the shaft frame **2512** is rotatably coupled to the shaft attachment module **2520** such that it may rotate relative thereto. The proximal end of the outer sleeve **2550** is rotatably coupled to the closure tube attachment yoke **2560** in the above described manners such that it may rotate relative thereto. In various forms, a nozzle **2590** may be employed in the above-described manners to rotate the shaft **2510** about the shaft axis SA-SA relative to the frame shaft attachment module **2520**.

As can be further seen in FIG. **68-70**, the proximal end **2577** of the intermediate firing shaft **2572** protrudes proximally out of the closure tube attachment yoke **2560** and has a shaft attachment lug **2578** formed thereon. The firing shaft attachment cradle **2413** formed in the distal end **2411** of the longitudinally moveable drive member **2410** is formed to enable the firing shaft attachment lug **2578** to be pivotally be loaded from the side.

As can be seen in FIG. **69**, the frame attachment module portion **2384** has a pair of pivot cradles **2385** formed therein that are adapted to receive corresponding pivot lugs **2529** formed on the shaft attachment module **2520**. When the lugs **2529** are supported within the pivot cradles **2385**, the shaft attachment module **2520** may be pivoted into operable engagement with the frame attachment module **2384** as illustrated in FIG. **70**. In particular, the lugs **2529** may define a pivot axis PA-PA that may be substantially transverse to the actuation axis AA-AA. See FIG. **73**. The shaft attachment module **2520** may have laterally protruding latch pins **2591** that are configured to latchingly engage corresponding latch pockets **2387** in the frame attachment module **2384**. To initiate the coupling process, the intermediate firing shaft **2572** is brought into operable engagement with the longitudinally movable drive member in a direction that is substantially transverse to the actuation axis AA-AA.

Once the shaft attachment module **2520** has been latched to the frame attachment module **2384** as shown in FIGS. **72** and **73**, the clinician may then couple the closure drive system (which may be similar to the closure drive systems described herein) to the closure tube attachment yoke **2560**.

The various interchangeable shaft arrangements disclosed herein represent vast improvements over prior surgical instrument arrangements that employ dedicated shafts. For example, one shaft arrangement may be used on multiple handle arrangements and/or with robotically controlled surgical systems. The methods of coupling the shaft arrangements also differ from prior shaft arrangements that employ bayonet connections and other structures that require the application of a rotary motion to the shaft and/or the handle or housing during the coupling process. The various exemplary descriptions of the coupling processes employed by the shaft assemblies disclosed herein include bringing a portion of the interchangeable shaft assembly into coupling engagement with a corresponding portion of a housing, a handle, and/or a frame in a direction or orientation that is substantially transverse to an actuation axis. These coupling processes are intended to encompass movement of either one or both of the shaft assembly and housing, handle and/or frame during the coupling process. For example, one method may encompass retaining the handle, housing and/or frame stationary while moving the shaft assembly into coupling engagement with it. Another method may encompass retaining the shaft assembly stationary while moving the handle, housing and/or frame into coupling engagement with it. Still another method may involve simultaneously moving the shaft assembly and the handle, housing and/or frame together into coupling engagement. It will be understood that the coupling procedures employed for coupling the various shaft assembly arrangements disclosed herein may encompass one or more (including all) of such variations.

Referring to FIGS. **75-80**, there is shown a handle **2642** that may be substantially identical to the handle **1042** described above, except that the frame attachment module or frame attachment portion **2684** of the frame **2680** includes a lockout assembly **2690** for preventing the inadvertent actuation of the closure drive system **1750**. As can be seen in FIGS. **75** and **76**, for example, a proximal lockout slot segment **2692** is formed in the frame attachment module **2684** such that, prior to attachment of the interchangeable shaft assembly **1900'** thereto, the corresponding attachment lug **1066** on the closure attachment bar **1764** is slidably received therein. Thus, when the closure attachment bar **1764** is in that position, the clinician is unable to actuate the closure drive system. Stated another way, when the actuation lug **1766** is received in the proximal lockout slot segment **2692**, the clinician is unable to actuate the closure trigger **1752**. In various forms, only one proximal lockout slot segment **2692** may be employed. In other forms, two proximal lockout slot segments **2692** are provided such that each attachment lug **1766** may be received in a corresponding proximal lockout slot segment **2692**. In various forms, a lockout spring **2695** may be employed to bias the linkage assembly **1760**, such that when the closure trigger **1752** is in the unactuated position, the closure attachment bar

1764 is biased to a position wherein at least one of the attachment lugs 1766 is received in the proximal lockout slot segment 2692.

As can be seen in FIGS. 77 and 78, the lockout assembly 2690 may further include a distal lug slot 2694 that is formed in the shaft attachment module 1920' and located such that, when the shaft attachment module 1920' has been completely attached to the frame 2680, the distal lug slot 2694 opens into the proximal lockout slot segment 2692 as shown in FIGS. 77 and 78.

Operation of the closure lockout assembly 2690 may be understood from reference to FIGS. 76-80. FIG. 76 illustrates the position of the closure attachment bar 1764 when the closure trigger 1752 is unactuated. As can be seen in that Figure, when in that position, the attachment lug 1766 is received within the proximal lockout slot segment 2692. Thus, if the clinician attempts to actuate the closure trigger 1752 when in that position (i.e., prior to operably attaching the interchangeable shaft assembly 1900' to the frame 2680 in operable engagement), the clinician will be unable to actuate the closure drive system 1750. After the clinician has attached the interchangeable shaft assembly 1900' to the frame 2684 such that it is fully seated and completely attached in operable engagement, the distal lockout slot segment 2694 in the shaft attachment module 1920" will open into the proximal lockout slot segment 2692 as shown in FIGS. 77 and 78. As the shaft attachment module 1920' is inserted into operable engagement with the frame attachment module 2684, the yoke arm 1961 protruding proximally from the closure tube attachment yoke 1960 will capture the attachment lug 1766 in the downwardly opening slot 1963 and drive it to the bottom of the proximal lockout slot 2692 as shown in FIG. 79. Thereafter, when the clinician desires to actuate the closure drive system 1750 by actuating the closure trigger 1752, the closure linkage assembly 1760 will be driven in the distal direction "D". As the closure attachment bar 1764 is advanced distally, the attachment lug 1766 is permitted to advance distally into the distal lockout slot 2694 for the distance necessary, for example, to result in the closure of the anvil or application of a corresponding actuation motion to the end effector operably coupled to the end effector shaft assembly 1900'. FIG. 80 illustrates the position of the closure attachment bar 1764 when the closure drive system 1750 has been fully actuated, for example, when the closure trigger 1752 has been fully depressed.

FIGS. 81-85 illustrate another lockout assembly 2690' for preventing the inadvertent actuation of the closure drive system 1750 until the interchangeable shaft assembly 1900' has been coupled in operable engagement with the frame 2680. In at least one form, a lockout shoulder 2696 is formed on the frame attachment module or frame attachment portion 2684' such that when the interchangeable shaft assembly 1900' has not been coupled in operable engagement with the frame 2680, the closure attachment bar 1764 is prevented from moving in the distal direction "D" by the shoulder 2696. See FIG. 81. As the shaft attachment module 1920' is inserted into operable engagement with the frame attachment module 2684', the yoke arm 1961 protruding proximally from the closure tube attachment yoke 1960 will capture the attachment lug 1766 on the closure attachment bar 1764 a move the closure attachment bar 1764 to the "unlocked" position shown in FIGS. 82 and 83. As can be particularly seen in FIG. 82, when in the unlocked position, the closure attachment bar 1764 is located below the shoulder 2696 on the frame attachment module 2684'. When the closure attachment bar is in the unlocked position, it may be advanced distally when the closure drive system 1750 is actuated by depressing the actuation trigger 1752.

FIGS. 86-91 illustrate another interchangeable shaft assembly 1900" and handle 2642 that employs a lockout assembly 2700 for preventing the inadvertent actuation of the closure drive system 1750". As can be seen in FIGS. 88 and 89, one form of lockout assembly 2700 includes an actuator slide member 2720 that is slidably journaled in a distally extending lock foot 2710 formed on the frame attachment module or frame attachment portion 2684". In particular, in at least one form, the actuator slide member 2720 has two laterally protruding slide tabs 2722 that are received in corresponding slots 2712 formed in the lock foot 2710. See FIG. 86. The actuator slide member 2720 is pivotally coupled to the closure attachment bar 1764" of the closure drive system 1750" and has an actuator pocket 2724 formed therein that is adapted to receive a downwardly-protruding actuator tab 2702 on the closure tube attachment yoke 1960'. As with the closure tube attachment yoke 1960 described above, the closure tube attachment closure yoke 1960' is rotatably affixed to the outer sleeve 1950 in the various manners described herein and which is axially movable within the shaft attachment module 1920'.

As can be seen in FIGS. 88-89, the lockout assembly 2700 may further include a movable lock member 2730 that is received in a cavity 2714 formed in the lock foot 2710. The lock member 2730 has a lock portion 2732 that is sized to extend into the actuator pocket 2724 such that when in that "locked" position, the lock member 2730 prevents the distal movement of the actuator slide member 2720 relative to the lock foot 2710. As can be most particularly seen in FIG. 89, a lock spring 2734 is provided in the cavity 2714 to bias the lock member 2730 into the locked position.

FIG. 89 illustrates the lockout assembly 2700 in the locked position. When in that position, the lock portion 2732 is located in the actuator pocket 2724 and thereby prevents the distal movement of the actuator slide member 2720. Thus, if the clinician attempts to actuate the closure drive system 1750" by depressing the closure trigger 1752, the lock portion 2732 will prevent the advancement of the slide member 2720. FIG. 90 illustrates the position of the lock member 2730 after the actuator tab 2702 on the closure tube yoke 1960' has been inserted into the actuator pocket 2724 and has biased the lock member 2370 into an "unlocked" position in the bottom of the cavity 2714 wherein the actuator slide member 2720 may be advanced distally. FIG. 91 illustrates the position of the actuator slide 2720 after the closure trigger 1752 has been completely depressed to thereby axially advance the closure tube attachment yoke 1960' and the outer sleeve 1950 attached thereto.

FIGS. 92-98 illustrate another interchangeable shaft assembly 1900" and handle 2642" that employs a lockout assembly 2800 for preventing the inadvertent actuation of the closure drive system 1750". The closure drive system 1750" may be similar to the closure drive systems 1050 and 1750 described above and include a closure trigger 1752 and a closure linkage assembly 1760'. The closure linkage assembly 1760' may include a closure link 1762' that is pivotally coupled to the closure attachment bar 1764. In addition, an actuator slide member 2720 may be pivotally attached to the closure attachment bar 1764 and also be slidably journaled in a distally extending lock foot 2710' formed on the frame attachment module 2684". In particular, in at least one form, the actuator slide member 2720 has two laterally protruding slide tabs 2722 that are received in corresponding slots 2712 formed in the lock foot 2710. See FIG. 92. The actuator slide member **2720** is pivotally coupled to the closure attachment bar **1764** of the closure drive system **1750"** and has an actuator pocket **2724** formed therein that is adapted to receive a downwardly-protruding actuator tab **2702** on the closure tube attachment yoke **1960'**. As with the closure tube attachment yoke **1960** described above, the closure tube attachment closure yoke **1960'** is rotatably affixed to the outer sleeve **1950** in the various manners described herein and which is axially movable within the shaft attachment module **1920"**.

In various forms, the lockout assembly **2800** may further include a movable lock bar or lock member **2802** that is pivotally attached to the frame attachment module **2684"**. For example, the lock bar **2802** may be pivotally mounted to a laterally protruding pin **2804** on the frame attachment module **2684"**. The lock bar **2802** may further have a lock pin **2806** protruding from a proximal portion thereof that is configured to extend into a lock slot **2808** provided in the closure link **1762'** when the closure drive system **1750"** in unactuated. See FIG. **94**. Lock pin **2806** may extend through a lock slot **2812** that is provided in a side plate **2810** that is attached to the frame **2680'**. The lock slot **2812** may serve to guide the lock pin **2806** between locked (FIGS. **92-94**) and unlocked positions (FIGS. **95-98**).

When the lockout assembly is in the locked position, the lock pin **2806** is received in the lock slot in **2808** in the closure link **1762'**. When in that position, the lock pin prevents movement closure linkage assembly **1760'**. Thus, if the clinician attempts to actuate the closure drive system **1750"** by depressing the closure trigger **1752**, the lock pin **2806** will prevent movement of the closure link **1762** and ultimately prevent the advancement of the slide member **2720**. FIGS. **95-98** illustrate the position of the lock bar **2602** after the shaft attachment module **1920"** has been coupled in operable engagement with the frame attachment module **2684"**. When in that position, a lock release portion **2820** on the frame attachment module **2684"** contacts the lock bar **2802** and causes it to pivot to thereby move the lock pin **2806** out of the lock slot **2808** in the closure link **1762'**. As can also be seen in FIGS. **97** and **98**, when the shaft attachment module **1920"** has been coupled in operable engagement with the frame attachment module **2684"**, the actuator tab **2702** on the closure tube yoke **1960'** is seated in the actuator pocket **2724** in the actuator slide member **2720**. FIG. **98** illustrates the position of the actuator slide member **2720** after the closure trigger **1752** has been completely depressed to thereby axially advance the closure tube attachment yoke **1960'** and the outer sleeve **1950** attached thereto in the distal direction "D".

Referring now to FIGS. **99-101**, there is shown a shaft locking assembly **2900** that is configured to prevent axial movement of the firing member **1270** unless the interchangeable shaft assembly has been coupled in operable engagement with the surgical instrument. More particularly, the shaft locking assembly **2900** may prevent axial movement of the firing member **1270** unless the firing member has been coupled in operable engagement with the longitudinally movable drive member **1110** (the longitudinally movable drive member **1110** may be seen in FIG. **88**). In at least one form, the shaft locking assembly **2900** may comprise a shaft locking member or locking plate **2902** that has a shaft clearance hole **2904** therethrough and is supported by a portion of the shaft attachment frame or module **1920"** for slidable travel in directions "LD" that are substantially transverse to the shaft axis SA-SA. See FIG. **99**. The shaft locking plate **2902** may, for example, move between a locked position shown in FIG. **100** wherein the shaft locking plate **2902** extends into the recessed area **1279** between the attachment lug **1278** and the proximal end **1277** of the intermediate firing shaft portion **1272**. When in that locked position, the shaft locking plate **2902** prevents any axial movement of the intermediate firing shaft portion **1272**. The shaft locking plate **2902** may be biased into the locked position by a lock spring **2906** or other biasing arrangement. Note that FIG. **99** illustrates the locking plate **2902** in an unlocked configuration for clarity purposes. When the interchangeable shaft assembly is not attached to a surgical instrument, the locking plate **2902** will be biased into the locked position as shown in FIG. **100**. It will be appreciated that such arrangement prevents any inadvertent axial movement of the firing member **1270** when the interchangeable shaft assembly has not been attached in operable engagement with a surgical instrument (e.g., hand-held instrument, robotic system, etc.).

As was discussed in detail above, during the coupling of the interchangeable shaft assembly to the surgical instrument, the attachment lug **1278** on the end of the intermediate firing shaft portion **1272** enters a cradle **1113** in the distal end of the longitudinally movable drive member **1110**. See FIG. **88**. As the attachment lug **1278** enters the cradle **1113**, the distal end of the longitudinally movable drive member **1110** contacts the shaft locking plate **2902** and moves it to an unlocked position (FIG. **101**) wherein the distal end of the longitudinally movable drive member **1110** and the proximal end **1277** of the intermediate firing shaft portion **1272** may axially move within the shaft clearance hole **2904** in response to actuation motions applied to the longitudinally movable drive member **1110**.

Turning now to FIGS. **102-112**, a surgical instrument, such as surgical instrument **10000**, and/or any other surgical instrument, such as surgical instrument system **1000**, for example, can comprise a shaft **10010** and an end effector **10020**, wherein the end effector **10020** can be articulated relative to the shaft **10010**. Further to the above, the surgical instrument **10000** can comprise a shaft assembly comprising the shaft **10010** and the end effector **10020** wherein the shaft assembly can be removably attached to a handle of the surgical instrument **10000**. Referring primarily to FIGS. **102-104**, the shaft **10010** can comprise a shaft frame **10012** and the end effector **10020** can comprise an end effector frame **10022** wherein the end effector frame **10022** can be rotatably coupled to the shaft frame **10012** about an articulation joint **10090**. With regard to the articulation joint **10090**, in at least one example, the shaft frame **10012** can comprise a pivot pin **10014** which can be received within a pivot aperture **10024** defined in the end effector frame **10022**. The end effector frame **10022** can further comprise a drive pin **10021** extending therefrom which can be operably engaged with an articulation driver. The drive pin **10021** can be configured to receive a force applied thereto and, depending on the direction in which the force is applied to the drive pin **10021**, rotate the end effector **10020** in a first direction or a second, opposite, direction. More particularly, when a force is applied to the drive pin **10021** in the distal direction by the articulation driver, the articulation driver can push the drive pin **10021** around the pivot pin **10014** and, similarly, when a force is applied to the drive pin **10021** in the proximal direction by the articulation driver, the articulation driver can pull the drive pin **10021** around the pivot pin **10014** in the opposite direction, for example. To the extent that the drive pin **10021** were to be placed on the opposite side of the articulation joint **10090**, for example, the distal and proximal movements of the articulation driver would produce an opposite effect on the end effector **10020**.

Further to the above, referring again to FIGS. **102-104**, the surgical instrument **10000** can comprise an articulation driver system including a proximal articulation driver **10030** and a distal articulation driver **10040**. When a drive force is transmitted to the proximal articulation driver **10030**, whether it be in the proximal direction or the distal direction, the drive force can be transmitted to the distal articulation driver **10040** through an articulation lock **10050**, as described in greater detail further below. In various circumstances, further to the above, a firing member **10060** of the surgical instrument **10000** can be utilized to impart such a drive force to the proximal articulation driver **10040**. For instance, referring primarily to FIGS. **102-112**, the surgical instrument **10000** can comprise a clutch system **10070** which can be configured to selectively connect the proximal articulation driver **10030** to the firing member **10060** such that the movement of the firing member **10060** can be imparted to the proximal articulation driver **10030**. In use, the clutch system **10070** can be movable between an engaged state (FIGS. **102-108** and **111**) in which the proximal articulation driver **10030** is operably engaged with the firing member **10060** and a disengaged state (FIGS. **109**, **110**, and **112**) in which the proximal articulation driver **10030** is not operably engaged with the firing member **10060**. In various circumstances, the clutch system **10070** can comprise an engagement member **10072** which can be configured to directly connect the proximal articulation driver **10030** to the firing member **10060**. The engagement member **10072** can comprise at least one drive tooth **10073** which can be received within a drive recess **10062** defined in the firing member **10060** when the clutch system **10070** is in its engaged state. In certain circumstances, referring primarily to FIGS. **28** and **31**, the engagement member **10072** can comprise a first drive tooth **10073** that extends to one side of the proximal articulation driver **10030** and a second drive tooth **10073** that extends to the other side of the proximal articulation driver **10030** in order to engage the drive recess **10062** defined in the firing member **10060**.

Further to the above, referring again to FIGS. **102-112**, the clutch system **10070** can further comprise an actuator member **10074** which can be configured to rotate or pivot the engagement member **10072** about a pivot pin **10071** mounted to a proximal end **10039** (FIG. **104**A) of the proximal articulation driver **10030**. The actuator member **10074** can comprise a first, or outer, projection **10076** and a second, or inner, projection **10077** between which can be defined a recess **10078** configured to receive a control arm **10079** defined in the engagement member **10072**. When the actuator member **10074** is rotated away from the firing member **10060**, i.e., away from a longitudinal axis of the shaft **10010**, the inner projection **10077** can contact the control arm **10079** of the engagement member **10072** and rotate the engagement member **10072** away from the firing member **10060** to move the drive teeth **10073** out of the drive notch **10062** and, as a result, disengage the engagement member **10072** from firing member **10060**. Concurrently, the engagement member **10072** can also be disengaged from the proximal articulation driver **10030**. In at least one circumstance, the proximal articulation driver **10030** can comprise a drive notch **10035** defined therein which can also be configured to receive a portion of the drive teeth **10073** when the engagement member **10072** is in an engaged position wherein, similar to the above, the drive teeth **10073** can be removed from the drive notch **10035** when the engagement member **10072** is moved into its disengaged position. In certain other circumstances, referring primarily to FIG. **108**, the drive teeth **10073** can define a recess **10083** therebetween which can be received in the drive notch **10035**. In either event, in a way, the engagement member **10072** can be configured to, one, simultaneously engage the drive notch **10035** in the proximal articulation driver **10030** and the drive notch **10062** in the firing member **10060** when the engagement member **10072** is in its engaged position and, two, be simultaneously disengaged from the drive notch **10035** and the drive notch **10062** when the engagement member **10072** is moved into its disengaged position. With continuing reference to FIGS. **102-104**, the actuator member **10074** can be rotatably or pivotably mounted to a housing at least partially surrounding the shaft **10010** via a pivot pin **10075**. In some circumstances, the pivot pin **10075** can be mounted to a handle frame **10001** and/or a handle housing surrounding the handle frame **10001**, such as a handle housing including portions **11002** and **11003** as illustrated in FIG. **131**, for example. The surgical instrument **10000** can further comprise a torsion spring **10080** at least partially surrounding said pivot pin **10075** which can be configured to impart a rotational bias to the actuator member **10074** in order to bias the actuator **10074**, and the engagement member **10072**, toward the firing member **10060** and to bias the engagement member **10072** into its engaged position. To this end, the outer projection **10076** of the actuator member **10074** can contact the control arm **10079** of the engagement member **10072** and pivot the engagement member **10072** inwardly about the pivot pin **10071**.

Upon comparing FIGS. **108** and **109**, further to the above, the reader will note that the clutch system **10070** has been moved between its engaged state (FIG. **108**) and its disengaged state (FIG. **109**). A similar comparison can be drawn between FIGS. **111** and **112** wherein the reader will appreciate that a closure tube **10015** of the shaft **10010** has been advanced from a proximal position (FIG. **111**) to a distal position (FIG. **112**) to move clutch system **10070** between its engaged state (FIG. **111**) and its disengaged state (FIG. **112**). More particularly, the actuator member **10074** can include a cam follower portion **10081** which can be contacted by the closure tube **10015** and displaced into its disengaged position when the closure tube **10015** is advanced distally to close an anvil, for example, of the end effector **10020**. The interaction of a closure tube and an anvil is discussed elsewhere in the present application and is not repeated herein for the sake of brevity. In various circumstances, referring primarily to FIG. **107**, the cam follower portion **10081** of the actuator member **10074** can be positioned within a window **10016** defined in the closure tube **10015**. When the clutch system **10070** is in its engaged state, the edge or sidewall **10017** of the window **10016** can contact the cam follower portion **10081** and pivot the actuator member **10074** about the pivot pin **10075**. In effect, the sidewall **10017** of the window **10016** can act as a cam as the closure tube **10015** is moved into its distal, or closed, position. In at least one circumstance, the actuator member **10074** can comprise a stop extending therefrom which can be configured to engage a housing of the handle, for example, and limit the travel of the actuator member **10074**. In certain circumstances, the shaft assembly can include a spring positioned intermediate the housing of the shaft assembly and a ledge **10082** extending from the actuator member **10074** which can be configured to bias the actuator member **10074** into its engaged position. In the distal, closed, position of the closure tube **10015**, discussed above, the closure tube **10015** can remain positioned underneath the cam follower portion **10081** to hold the clutch system **10070** in its disengaged state. In such a disengaged state, the movement of the firing member **10060** is not transferred to the proximal articulation driver **10030**, and/or any other portion of the articulation driver system. When the closure tube **10015** is retracted back into its proximal, or open, position, the closure tube **10015** can be removed from underneath the cam follower portion **10081** of the actuator member **10074** such that the spring **10080** can bias the actuator member **10074** back into the window **10016** and allow the clutch system **10070** to re-enter into its engaged state.

When the proximal articulation driver **10030** is operatively engaged with the firing member **10060** via the clutch system **10070**, further to the above, the firing member **10060** can move the proximal articulation driver **10030** proximally and/or distally. For instance, proximal movement of the firing member **10060** can move the proximal articulation driver **10030** proximally and, similarly, distal movement of the firing member **10060** can move the proximal articulation driver **10030** distally. Referring primarily to FIGS. **102-104**, movement of the proximal articulation driver **10030**, whether it be proximal or distal, can unlock the articulation lock **10050**, as described in greater detail further below. With principal reference to FIG. **102**, the articulation lock **10050** can comprise a frame which is co-extensive with a frame **10042** of the distal articulation driver **10040**. Collectively, the frame of the articulation lock **10050** and the frame **10042** can be collectively referred to hereinafter as frame **10042**. The frame **10042** can comprise a first, or distal, lock cavity **10044** and a second, or proximal, lock cavity **10046** defined therein, wherein the first lock cavity **10044** and the second lock cavity **10046** can be separated by an intermediate frame member **10045**. The articulation lock **10050** can further include at least one first lock element **10054** at least partially positioned within the first lock cavity **10044** which can be configured to inhibit or prevent the proximal movement of the distal articulation driver **10040**. With regard to the particular embodiment illustrated in FIGS. **102-104**, there are three first lock elements **10054** positioned within the first lock cavity **10044** which can all act in a similar, parallel manner and can co-operatively act as a single lock element. Other embodiments are envisioned which can utilize more than three or less than three first lock elements **10054**. Similarly, the articulation lock **10050** can further include at least one second lock element **10056** at least partially positioned within the second lock cavity **10046** which can be configured to inhibit or prevent the distal movement of the distal articulation driver **10040**. With regard to the particular embodiment illustrated in FIGS. **102-104**, there are three second lock elements **10056** positioned within the second lock cavity **10046** which can all act in a similar, parallel manner and can co-operatively act as a single lock element. Other embodiments are envisioned which can utilize more than three or less than three second lock elements **10056**.

Further to the above, referring primarily to FIG. **104**A, each first lock element **10054** can comprise a lock aperture **10052** and a lock tang **10053**. The lock tang **10053** can be disposed within the first lock cavity **10044** and the lock aperture **10052** can be slidably engaged with a frame rail **10011** mounted to the shaft frame **10012**. Referring again to FIG. **102**, the frame rail **10011** extends through the apertures **10052** in the first lock elements **10054**. As the reader will note, with further reference to FIG. **102**, the first lock elements **10054** are not oriented in a perpendicular arrangement with the frame rail **10011**; rather, the first lock elements **10054** are arranged and aligned at a non-perpendicular angle with respect to the frame rail **10011** such that the edges or sidewalls of the lock apertures **10052** are engaged with the frame rail **10011**. Moreover, the interaction between the sidewalls of the lock apertures **10052** and the frame rail **10011** can create a resistive or friction force therebetween which can inhibit relative movement between the first lock elements **10054** and the frame rail **10011** and, as a result, resist a proximal pushing force P applied to the distal articulation driver **10040**. Stated another way, the first lock elements **10054** can prevent or at least inhibit the end effector **10020** from rotating in a direction indicated by arrow **10002**. If a torque is applied to the end effector **10020** in the direction of arrow **10002**, a proximal pushing force P will be transmitted from the drive pin **10021** extending from the frame **10022** of the end effector **10024** to the frame **10042** of the distal articulation driver **10040**. In various circumstances, the drive pin **10021** can be closely received within a pin slot **10043** defined in the distal end **10041** of the distal articulation driver **10040** such that the drive pin **10021** can bear against a proximal sidewall of the pin slot **10043** and transmit the proximal pushing force P to the distal articulation driver **10040**. Further to the above, however, the proximal pushing force P will only serve to bolster the locking engagement between the first lock elements **10054** and the frame rail **10011**. More particularly, the proximal pushing force P can be transmitted to the tangs **10053** of the first lock elements **10054** which can cause the first lock elements **10054** to rotate and decrease the angle defined between first lock elements **10054** and the frame rail **10011** and, as a result, increase the bite between the sidewalls of the lock apertures **10052** and the frame rail **10011**. Ultimately, then, the first lock elements **10054** can lock the movement of the distal articulation driver **10040** in one direction.

In order to release the first lock elements **10054** and permit the end effector **10020** to be rotated in the direction indicated by arrow **10002**, referring now to FIG. **103**, the proximal articulation driver **10030** can be pulled proximally to straighten, or at least substantially straighten, the first lock elements **10054** into a perpendicular, or at least substantially perpendicular, position. In such a position, the bite, or resistive force, between the sidewalls of the lock apertures **10052** and the frame rail **10011** can be sufficiently reduced, or eliminated, such that the distal articulation driver **10040** can be moved proximally. In order to straighten the first lock elements **10054** into the position illustrated in FIG. **103**, the proximal articulation driver **10030** can be pulled proximally such that a distal arm **10034** of the proximal articulation driver **10030** contacts the first lock elements **10054** to pull and rotate the first lock elements **10054** into their straightened position. In various circumstances, the proximal articulation driver **10030** can continue to be pulled proximally until a proximal arm **10036** extending therefrom contacts, or abuts, a proximal drive wall **10052** of the frame **10042** and pulls the frame **10042** proximally to articulate the end effector **10002**. In essence, a proximal pulling force can be applied from the proximal articulation driver **10030** to the distal articulation driver **10040** through the interaction between the proximal arm **10036** and the proximal drive wall **10052** wherein such a pulling force can be transmitted through the frame **10042** to the drive pin **10021** to articulate the end effector **10020** in the direction indicated by arrow **10002**. After the end effector **10020** has been suitably articulated in the direction of arrow **10002**, the proximal articulation driver **10040** can be released, in various circumstances, to permit the articulation lock **10050** to re-lock the distal articulation member **10040**, and the end effector **10020**, in position. In various circumstances, the articulation lock **10050** can comprise a spring **10055** positioned intermediate the group of first lock elements **10054** and the group of second lock elements **10056** which can be compressed when the first lock elements **10054** are straightened to unlock the proximal movement of the distal articulation driver **10040**, as discussed above. When the proximal articulation driver **10030** is released, the spring **10055** can resiliently re-expand to push the first lock elements **10054** into their angled positions illustrated in FIG. **102**.

Concurrent to the above, referring again to FIGS. **102** and **103**, the second lock elements **10056** can remain in an angled position while the first lock elements **10054** are locked and unlocked as described above. The reader will appreciate that, although the second lock elements **10056** are arranged and aligned in an angled position with respect to the shaft rail **10011**, the second lock elements **10056** are not configured to impede, or at least substantially impede, the proximal motion of the distal articulation driver **10040**. When the distal articulation driver **10040** and articulation lock **10050** are slid proximally, as described above, the second lock elements **10056** can slide distally along the frame rail **10011** without, in various circumstances, changing, or at least substantially changing, their angled alignment with respect to the frame rail **10011**. While the second lock elements **10056** are permissive of the proximal movement of the distal articulation driver **10040** and the articulation lock **10050**, the second lock elements **10056** can be configured to selectively prevent, or at least inhibit, the distal movement of the distal articulation driver **10040**, as discussed in greater detail further below.

Similar to the above, referring primarily to FIG. **104**A, each second lock element **10056** can comprise a lock aperture **10057** and a lock tang **10058**. The lock tang **10058** can be disposed within the second lock cavity **10046** and the lock aperture **10057** can be slidably engaged with the frame rail **10011** mounted to the shaft frame **10012**. Referring again to FIG. **102**, the frame rail **10011** extends through the apertures **10057** in the second lock elements **10056**. As the reader will note, with further reference to FIG. **102**, the second lock elements **10056** are not oriented in a perpendicular arrangement with the frame rail **10011**; rather, the second lock elements **10056** are arranged and aligned at a non-perpendicular angle with respect to the frame rail **10011** such that the edges or sidewalls of the lock apertures **10057** are engaged with the frame rail **10011**. Moreover, the interaction between the sidewalls of the lock apertures **10057** and the frame rail **10011** can create a resistive or friction force therebetween which can inhibit relative movement between the second lock elements **10056** and the frame rail **10011** and, as a result, resist a distal force D applied to the distal articulation driver **10040**. Stated another way, the second lock elements **10056** can prevent or at least inhibit the end effector **10020** from rotating in a direction indicated by arrow **10003**. If a torque is applied to the end effector **10020** in the direction of arrow **10003**, a distal pulling force D will be transmitted from the drive pin **10021** extending from the frame **10022** of the end effector **10024** to the frame **10042** of the distal articulation driver **10040**. In various circumstances, the drive pin **10021** can be closely received within the pin slot **10043** defined in the distal end **10041** of the distal articulation driver **10040** such that the drive pin **10021** can bear against a distal sidewall of the pin slot **10043** and transmit the distal pulling force D to the distal articulation driver **10040**. Further to the above, however, the distal pulling force D will only serve to bolster the locking engagement between the second lock elements **10056** and the frame rail **10011**. More particularly, the distal pulling force D can be transmitted to the tangs **10058** of the second lock elements **10056** which can cause the second lock elements **10056** to rotate and decrease the angle defined between second lock elements **10056** and the frame rail **10011** and, as a result, increase the bite between the sidewalls of the lock apertures **10057** and the frame rail **10011**. Ultimately, then, the second lock elements **10056** can lock the movement of the distal articulation driver **10040** in one direction.

In order to release the second lock elements **10056** and permit the end effector **10020** to be rotated in the direction indicated by arrow **10003**, referring now to FIG. **104**, the proximal articulation driver **10030** can be pushed distally to straighten, or at least substantially straighten, the second lock elements **10056** into a perpendicular, or at least substantially perpendicular, position. In such a position, the bite, or resistive force, between the sidewalls of the lock apertures **10057** and the frame rail **10011** can be sufficiently reduced, or eliminated, such that the distal articulation driver **10040** can be moved distally. In order to straighten the second lock elements **10056** into the position illustrated in FIG. **104**, the proximal articulation driver **10030** can be pushed distally such that the proximal arm **10036** of the proximal articulation driver **10030** contacts the second lock elements **10056** to push and rotate the second lock elements **10056** into their straightened position. In various circumstances, the proximal articulation driver **10030** can continue to be pushed distally until the distal arm **10034** extending therefrom contacts, or abuts, a distal drive wall **10051** of the frame **10042** and pushes the frame **10042** distally to articulate the end effector **10020**. In essence, a distal pushing force can be applied from the proximal articulation driver **10030** to the distal articulation driver **10040** through the interaction between the distal arm **10034** and the distal drive wall **10051** wherein such a pushing force can be transmitted through the frame **10042** to the drive pin **10021** to articulate the end effector **10020** in the direction indicated by arrow **10003**. After the end effector **10020** has been suitably articulated in the direction of arrow **10003**, the proximal articulation driver **10040** can be released, in various circumstances, to permit the articulation lock **10050** to re-lock the distal articulation member **10040**, and the end effector **10020**, in position. In various circumstances, similar to the above, the spring **10055** positioned intermediate the group of first lock elements **10054** and the group of second lock elements **10056** can be compressed when the second lock elements **10056** are straightened to unlock the distal movement of the distal articulation driver **10040**, as discussed above. When the proximal articulation driver **10040** is released, the spring **10055** can resiliently re-expand to push the second lock elements **10056** into their angled positions illustrated in FIG. **102**.

Concurrent to the above, referring again to FIGS. **102** and **104**, the first lock elements **10054** can remain in an angled position while the second lock elements **10056** are locked and unlocked as described above. The reader will appreciate that, although the first lock elements **10054** are arranged and aligned in an angled position with respect to the shaft rail **10011**, the first lock elements **10054** are not configured to impede, or at least substantially impede, the distal motion of the distal articulation driver **10040**. When the distal articulation driver **10040** and articulation lock **10050** are slid distally, as described above, the first lock elements **10054** can slide distally along the frame rail **10011** without, in various circumstances, changing, or at least substantially changing, their angled alignment with respect to the frame rail **10011**. While the first lock elements **10054** are permissive of the distal movement of the distal articulation driver **10040** and the articulation lock **10050**, the first lock elements **10054** are configured to selectively prevent, or at least inhibit, the proximal movement of the distal articulation driver **10040**, as discussed above.

In view of the above, the articulation lock **10050**, in a locked condition, can be configured to resist the proximal and distal movements of the distal articulation driver **10040**. In terms of resistance, the articulation lock **10050** can be configured to prevent, or at least substantially prevent, the proximal and distal movements of the distal articulation driver **10040**. Collectively, the proximal motion of the distal articulation driver **10040** is resisted by the first lock elements **10054** when the first lock elements **10054** are in their locked orientation and the distal motion of the distal articulation driver **10040** is resisted by the second lock elements **10056** when the second lock elements **10056** are in their locked orientation, as described above. Stated another way, the first lock elements **10054** comprise a first one-way lock and the second lock elements **10056** comprise a second one-way lock which locks in an opposite direction.

When the first lock elements **10054** are in a locked configuration, referring again to FIG. **102** and as discussed above, an attempt to move the distal articulation driver **10040** proximally may only serve to further decrease the angle between the first lock elements **10054** and the frame rail **10011**. In various circumstances, the first lock elements **10054** may flex while, in at least some circumstances, the first lock elements **10054** may abut a distal shoulder **10047** defined in the first lock cavity **10044**. More precisely, the outer-most first lock element **10054** may abut the distal shoulder **10047** while the other first lock elements **10054** may abut an adjacent first lock element **10054**. In some circumstances, the distal shoulder **10047** can arrest the movement of the first lock elements **10054**. In certain circumstances, the distal shoulder **10047** can provide strain relief. For instance, once the distal shoulder **10047** is in contact with the first lock elements **10054**, the distal shoulder **10047** can support the first lock elements **10054** at a location which is adjacent to, or at least substantially adjacent to, the lock rail **10011** such that only a small lever arm, or torque arm, separates opposing forces transmitted through the first lock elements **10054** at different locations thereof. In such circumstances, in effect, the force transmitted through the tangs **10053** of the first lock elements **10054** may be reduced or eliminated.

Similar to the above, when the second lock elements **10056** are in a locked configuration, referring again to FIG. **102** and as discussed above, an attempt to move the distal articulation driver **10040** distally may only serve to further decrease the angle between the second lock elements **10056** and the frame rail **10011**. In various circumstances, the second lock elements **10056** may flex while, in at least some circumstances, the second lock elements **10056** may abut a proximal shoulder **10048** defined in the second lock cavity **10046**. More precisely, the outer-most second lock element **10056** may abut the proximal shoulder **10048** while the other second lock elements **10056** may abut an adjacent second lock element **10056**. In some circumstances, the proximal shoulder **10048** can arrest the movement of the second lock elements **10056**. In certain circumstances, the proximal shoulder **10048** can provide strain relief. For instance, once the proximal shoulder **10048** is in contact with the second lock elements **10056**, the proximal shoulder **10048** can support the second lock elements **10056** at a location which is adjacent to, or at least substantially adjacent to, the lock rail **10011** such that only a small lever arm, or torque arm, separates opposing forces transmitted through the second lock elements **10056** at different locations thereof. In such circumstances, in effect, the force transmitted through the tangs **10058** of the second lock elements **10056** may be reduced or eliminated.

Discussed in connection with the exemplary embodiment illustrated in FIGS. **102-112**, an initial proximal movement of the proximal articulation driver **10030** can unlock the proximal movement of the distal articulation driver **10040** and the articulation lock **10050** while a further proximal movement of the proximal articulation driver **10030** can drive the distal articulation driver **10040** and the articulation lock **10050** proximally. Similarly, an initial distal movement of the proximal articulation driver **10030** can unlock the distal movement of the distal articulation driver **10040** and the articulation lock **10050** while a further distal movement of the proximal articulation driver **10030** can drive the distal articulation driver **10040** and the articulation lock **10050** distally. Such a general concept is discussed in connection with several additional exemplary embodiments disclosed below. To the extent that such discussion is duplicative, or generally cumulative, with the discussion provided in connection with the exemplary embodiment disclosed in FIGS. **102-112**, such discussion is not reproduced for the sake of brevity.

Turning now to FIGS. **113** and **114**, a surgical instrument, such as surgical instrument **10000**, and/or any other surgical instrument system, for example, can comprise a proximal articulation driver **10130**, a distal articulation driver **10140**, and an articulation lock **10150**. The articulation lock **10150** can comprise a frame **10152** which can include a slot, or lock channel, **10151** defined therein configured to receive at least a portion of the proximal articulation driver **10130** and at least a portion of the distal articulation driver **10140**. The articulation lock **10150** can further comprise a first lock element **10154** positioned within a first, or distal, lock cavity **10144** and a second lock element **10155** positioned within a second, or proximal, lock cavity **10146**. Similar to the above, the first lock element **10154** can be configured to resist a proximal pushing force P transmitted through the distal articulation driver **10140**. To this end, the distal articulation driver **10140** can include a lock recess **10145** defined therein which can include one or more lock surfaces configured to engage the first lock element **10154** and prevent the movement of the distal articulation driver **10140** relative to the lock frame **10152**. More specifically, a sidewall of the lock recess **10145** can comprise a first, or distal, lock surface **10141** which can be configured to wedge the first lock element **10154** against a sidewall, or lock wall, **10153** of the lock channel **10151** and, owing to this wedged relationship, the distal articulation driver **10140** may not be able to pass between the first lock element **10154** and the opposing sidewall **10157** of the lock channel **10151**. The reader will appreciate that the lock recess **10145** is contoured such that it gradually decreases in depth toward the distal end of the lock recess **10145** wherein, correspondingly, the distal articulation driver **10140** gradually increases in thickness toward the distal end of the lock recess **10145**. As a result, a proximal pushing force P applied to the distal articulation driver **10140** may only serve to further increase the resistance, or wedging force, holding the distal articulation driver **10140** in position.

In order to pull the distal articulation driver **10140** proximally, the proximal articulation driver **10130** can be configured to, one, displace the distal lock element **10154** proximally to unlock the articulation lock **10150** in the proximal direction and, two, directly engage the distal articulation driver **10140** and apply a proximal pulling force thereto. More specifically, further to the above, the proximal articulation driver **10130** can comprise a distal arm **10134** configured to initially engage the first lock element **10154** and a proximal arm **10136** which can be configured to then engage a proximal drive wall **10147** defined at the proximal end of the lock recess **10145** and pull the distal articulation driver **10140** proximally. Similar to the above, the proximal movement of the distal articulation driver **10140** can be configured to articulate the end effector of the surgical instrument. Once the end effector has been suitably articulated, the proximal articulation driver **10130** can be released, in various circumstances, to permit a spring **10155** positioned intermediate the first lock element **10154** and the second lock element **10156** to expand and sufficiently re-position the first lock element **10154** relative to the first lock surface **10141** and re-lock the distal articulation driver **10140** and the end effector in position.

Concurrent to the above, the second lock element **10156** may not resist, or at least substantially resist, the proximal movement of the distal articulation driver **10140**. When the articulation lock **10150** is in a locked condition, the second lock element **10156** may be positioned between a second, or proximal, lock surface **10143** of the lock recess **10145** and the lock wall **10153** of the lock channel **10151**. As the distal articulation driver **10140** is pulled proximally by the proximal articulation driver **10130**, further to the above, a dwell portion **10142** of the lock recess **10145** may move over the second lock element **10156**. In various circumstances, the dwell portion **10142** of the lock recess **10145** may comprise the widest portion of the recess **10145** which may, as a result, permit relative sliding movement between the distal articulation driver **10140** and the second lock element **10156** as the distal articulation driver **10140** is pulled proximally. In some circumstances, the second lock element **10156** can be configured to roll within the dwell portion **10142** thereby reducing the resistance force between the distal articulation driver **10140** and the second lock element **10156**. As the reader will appreciate, the second lock element **10156** may be permissive to the proximal movement of the distal articulation driver **10140** but can be configured to selectively resist the distal movement of the distal articulation driver **10140** as discussed in greater detail further below.

Similar to the above, the second lock element **10156** can be configured to resist a distal pulling force D transmitted through the distal articulation member **10140**. To this end, the second lock surface **10143** of the lock recess **10145** can be configured to wedge the second lock element **10156** against the lock wall **10153** of the lock channel **10151** and, owing to this wedged relationship, the distal articulation driver **10140** may not be able to pass between the second lock element **10156** and the opposing sidewall **10157** of the lock channel **10151**. The reader will appreciate that the lock recess **10145** is contoured such that it gradually decreases in depth toward the proximal end of the lock recess **10145** wherein, correspondingly, the distal articulation driver **10140** gradually increases in thickness toward the proximal end of the lock recess **10145**. As a result, a distal pulling force D applied to the distal articulation driver **10140** may only serve to further increase the resistance, or wedging force, holding the distal articulation driver **10140** in position.

In order to push the distal articulation driver **10140** distally, the proximal articulation driver **10130** can be configured to, one, displace the second lock element **10156** distally to unlock the articulation lock **10150** in the distal direction and, two, directly engage the distal articulation driver **10140** and apply a distal pushing force thereto. More specifically, further to the above, the proximal arm **10136** of the proximal articulation driver **10130** can be configured to initially engage the second lock element **10156** wherein the distal arm **10134** can then engage a distal drive wall **10148** defined at the distal end of the lock recess **10145** and push the distal articulation driver **10140** distally. Similar to the above, the distal movement of the distal articulation driver **10140** can be configured to articulate the end effector of the surgical instrument. Once the end effector has been suitably articulated, the proximal articulation driver **10130** can be released, in various circumstances, to permit the spring **10155** to expand and sufficiently re-position the second lock element **10156** relative to the second lock surface **10143** in order to re-lock the distal articulation driver **10140** and the end effector in position.

Concurrent to the above, the first lock element **10154** may not resist, or at least substantially resist, the distal movement of the distal articulation driver **10140**. When the articulation lock **10150** is in a locked condition, the first lock element **10154** may be positioned between the first lock surface **10141** of the lock recess **10145** and the lock wall **10153** of the lock channel **10151**, as discussed above. As the distal articulation driver **10140** is pushed distally by the proximal articulation driver **10130**, further to the above, the dwell portion **10142** of the lock recess **10145** may move over the first lock element **10154**. In various circumstances, the dwell portion **10142** may permit relative sliding movement between the distal articulation driver **10140** and the first lock element **10154** as the distal articulation driver **10140** is pushed distally. In some circumstances, the first lock element **10154** can be configured to roll within the dwell portion **10142** thereby reducing the resistance force between the distal articulation driver **10140** and the first lock element **10154**. As the reader will appreciate, the first lock element **10154** may be permissive to the distal movement of the distal articulation driver **10140** but can selectively resist the proximal movement of the distal articulation driver **10140**, as discussed above.

Further to the above, the first lock surface **10141**, the dwell **10142**, and the second lock surface **10143** of the lock recess **10145** can define a suitable contour. Such a contour can be defined by first, second, and third flat surfaces which comprise the first lock surface **10141**, the dwell **10142**, and the second lock surface **10143**, respectively. In such circumstances, definitive breaks between the first lock surface **10141**, the dwell **10142**, and the second lock surface **10143** can be identified. In various circumstances, the first lock surface **10141**, the dwell **10142**, and the second lock surface **10143** can comprise a continuous surface, such as an arcuate surface, for example, wherein definitive breaks between the first lock surface **10141**, the dwell **10142**, and the second lock surface **10143** may not be present.

Turning now to FIGS. **115** and **116**, a surgical instrument, such as surgical instrument **10000**, and/or any other surgical instrument system, for example, can comprise a shaft **10210**, an articulation driver system comprising a proximal articulation driver **10230** and a distal articulation driver **10240**, and an articulation lock **10250** configured to releasably hold the distal articulation driver **10240** in position. The general operation of the articulation driver system is the same as, or at least substantially similar to, the articulation driver system discussed in connection with the embodiment disclosed in FIGS. **113** and **114** and, as a result, such discussion is not repeated herein for the sake of brevity. As the reader will appreciate, referring to FIGS. **115** and **116**, the articulation lock **10250** can comprise a first lock element **10254** which can provide a one-way lock configured to releasably inhibit the proximal movement of the distal articulation driver **10240** and a second lock element **10256** which can provide a second one-way lock configured to releasably inhibit the distal movement of the distal articulation driver **10240**. Similar to the above, the first lock element **10254** and the second lock element **10256** can be positioned within a lock recess **10245** defined in the distal articulation driver **10240** and can be biased into a locked condition by a biasing member, or spring, **10255**, for example. In order to unlock the first lock element **10254**, similar to the above, the proximal articulation driver **10230** can be pulled proximally such that a distal hook **10234** contacts the first lock element **10254** and pulls the first lock element **10254** proximally. Thereafter, the proximal articulation driver **10230** can be pulled further proximally until the distal hook **10234** contacts the distal articulation driver frame **10242** and pulls the distal articulation driver **10240** proximally and articulates the end effector **10020**, similar to the embodiments described above. In order to unlock the second lock element **10256**, similar to the above, the proximal articulation driver **10230** can be pushed distally such that a proximal hook **10236** contacts the second lock element **10256** and pushes the second lock element **10256** distally. Thereafter, the proximal articulation driver **10230** can be pushed further distally until the proximal hook **10236** contacts the distal articulation driver frame **10242** and pushes the distal articulation driver **10240** distally and articulate the end effector **10020** in an opposite direction, similar to the embodiments described above. In various circumstances, the first lock element **10254** and the second lock element **10256** can each comprise a rotatable spherical element, or bearing, for example, which can be configured to reduce the sliding friction between the lock elements **10254**, **10256**, the shaft frame **10212**, the proximal articulation driver **10230**, and/or the distal articulation driver **10240**.

Turning now to FIGS. **125-130**, a surgical instrument, such as surgical instrument **10000**, and/or any other surgical instrument system, for example, can comprise an articulation driver system comprising a proximal articulation driver **10330** and a distal articulation driver **10340**, and an articulation lock **10350** configured to releasably hold the distal articulation driver **10340** in position. In many aspects, the general operation of the articulation driver system is the same as, or at least substantially similar to, the articulation driver system discussed in connection with the embodiments disclosed above and, as a result, such aspects are not repeated herein for the sake of brevity. As the reader will appreciate, primarily referring to FIGS. **125** and **126**, the articulation lock **10350** can comprise a first lock element **10354** which can provide a one-way lock configured to releasably inhibit the proximal movement of the distal articulation driver **10340** and a second lock element **10356** which can provide a second one-way lock configured to releasably inhibit the distal movement of the distal articulation driver **10340**. Similar to the above, the first lock element **10354** can be positioned within a first, or distal, lock recess **10344** and the second lock element **10356** can be positioned within a second, or proximal, lock recess **10346** defined in the distal articulation driver **10340** and can be biased into a locked condition by a biasing member, or spring, **10355**, for example. In order to unlock the first lock element **10354**, referring generally to FIG. **129**, the proximal articulation driver **10330** can be pulled proximally such that a distal hook **10334** contacts the first lock element **10354** and pulls the first lock element **10354** proximally. Thereafter, as illustrated in FIG. **129**, the proximal articulation driver **10330** can be pulled further proximally until the first lock element **10354** contacts an intermediate shoulder **10345** extending from a frame **10342** of the articulation driver frame **10340** and pulls the distal articulation driver **10340** proximally to articulate the end effector, similar to the embodiments described above. Once the end effector has been sufficiently articulated, the proximal articulation driver **10330** can be released which can permit the biasing spring **10355** to displace the lock elements **10354** and **10356** away from each other and seat the lock elements **10354** and **10356** in a locked condition, as illustrated in FIG. **130**. In order to unlock the second lock element **10356**, referring generally to FIG. **127**, the proximal articulation driver **10330** can be pushed distally such that a proximal hook **10336** contacts the second lock element **10356** and pushes the second lock element **10356** distally. Thereafter, the proximal articulation driver **10330** can be pushed further distally until the second lock element **10356** contacts the intermediate shoulder **10345** of the distal articulation driver frame **10342** and pushes the distal articulation driver **10340** distally to articulate the end effector in an opposite direction, similar to the embodiments described above. Once the end effector has been sufficiently articulated, similar to the above, the proximal articulation driver **10330** can be released which can permit the biasing spring **10355** to displace the lock elements **10354** and **10356** away from each other and seat the lock elements **10354** and **10356** in a locked condition, as illustrated in FIG. **128**.

In various circumstances, further to the above, the first lock element **10354** and the second lock element **10356** can each comprise a wedge, for example, which can be configured to lock the distal articulation driver **10340** in position. Referring primarily again to FIGS. **125** and **126**, the articulation lock **10350** can comprise a frame **10352** including a lock channel **10351** defined therein which can be configured to receive at least a portion of the proximal articulation driver **10330** and at least a portion of the distal articulation driver **10340**. The first lock cavity **10344**, further to the above, can be defined between the distal articulation driver **10340** and a lock wall **10353** of the lock channel **10351**. When a proximal load P is transmitted to the distal articulation driver **10340** from the end effector, the distal articulation driver **10340** can engage a wedge portion **10358** of the first lock element **10354** and bias the first lock element **10354** against the lock wall **10353**. In such circumstances, the proximal load P may only increase the wedging force holding the first lock element **10354** in position. In effect, the first lock element **10354** can comprise a one-way lock which can inhibit the proximal movement of the distal articulation driver **10340** until the first lock element **10354** is unlocked, as described above. When the first lock element **10354** is unlocked and the distal articulation driver **10340** is being moved proximally, the second lock element **10356** may not resist, or at least substantially resist, the proximal movement of the distal articulation driver **10340**. Similar to the above, the second lock cavity **10346**, further to the above, can be defined between the distal articulation driver **10340** and the lock wall **10353**. When a distal load D is transmitted to the distal articulation driver **10340** from the end effector, the distal articulation driver **10340** can engage a wedge portion **10359** of the second lock element **10356** and bias the second lock element **10356** against the lock wall **10353**. In such circumstances, the distal load D may only increase the wedging force holding the second lock element **10356** in position. In effect, the second lock element **10356** can comprise a one-way lock which can inhibit the distal movement of the distal articulation driver **10340** until the second lock element **10356** is unlocked, as described above. When the second lock element **10356** is unlocked and the distal articulation driver **10340** is being moved distally, the first lock element **10354** may not resist, or at least substantially resist, the distal movement of the distal articulation driver **10340**.

Turning now to FIGS. **117-124**, a surgical instrument, such as surgical instrument **10000**, and/or any other surgical instrument system, for example, can comprise an articulation driver system comprising a proximal articulation driver **10430** and a distal articulation driver **10440**, and an articulation lock **10450** configured to releasably hold the distal articulation driver **10440** in position. As the reader will appreciate, primarily referring to FIGS. **117** and **118**, the articulation lock **10450** can comprise a first lock cam **10454** which can provide a one-way lock configured to releasably inhibit the distal movement of the distal articulation driver **10440** and a second lock cam **10456** which can provide a second one-way lock configured to releasably inhibit the proximal movement of the distal articulation driver **10440**. The first lock cam **10454** can be rotatably mounted to the distal articulation driver **10440** and can include a projection **10457** rotatably positioned within a pivot aperture **10447** defined in the distal articulation driver **10440**. Similarly, the second lock cam **10456** can be rotatably mounted to the distal articulation driver **10440** and can include a projection **10458** rotatably positioned within a pivot aperture **10448** which is also defined in the distal articulation driver **10440**. The articulation lock **10450** can further comprise a frame **10452** having a lock channel **10451** defined therein which can be configured to receive at least a portion of the proximal articulation driver **10430**, at least a portion of the distal articulation driver **10440**, the first lock cam **10454**, and the second lock cam **10456**. The lock channel **10451** can comprise a first lock wall **10453** and a second lock wall **10459** wherein, when the articulation lock **10450** is in a locked state, the first lock cam **10454** can be biased into engagement with the first lock wall **10453** and the second lock cam **10456** can be biased into engagement with the second lock wall **10459**. The first lock cam **10454** can be configured to bias a first bearing point **10445** of the distal articulation driver **10440** against the second lock wall **10459** when the first lock cam **10454** is in its locked position. Similarly, the second lock cam **10456** can be configured to bias a second bearing point **10446** of the distal articulation driver **10440** against the first lock wall **10453** when the second lock cam **10454** is in its locked position. Such a locked state is illustrated in FIG. **119**. As also illustrated in FIG. **119**, the articulation lock **10450** can be biased into a locked state by a spring **10455**. The spring **10455** can be configured to rotate the first lock cam **10454** about its projection **10457** such that a lobe of the first lock cam **10454** engages the first lock wall **10453** and, similarly, to rotate the second lock cam **10456** about its projection **10458** such that a lobe of the second lock cam **10456** engages the second lock wall **10459**. In various circumstances, the first lock cam **10454** and the second lock cam **10456** can each comprise a spring aperture **10449** defined therein which can be configured to receive an end of the spring **10455** such that the spring **10455** can apply the biasing forces discussed above.

In order to unlock the first lock cam **10454**, referring generally to FIG. **120**, the proximal articulation driver **10430** can be pushed distally such that a distal drive shoulder **10434** of the proximal articulation driver **10430** contacts the first lock cam **10454** and pushes the first lock cam **10454** distally. In various circumstances, the first lock cam **10454** can comprise a drive pin **10437** extending therefrom which can be contacted by the distal drive shoulder **10434** such that, as the proximal articulation driver **10430** is pushed distally, the first lock cam **10454** and the distal articulation driver **10440** can be slid distally relative to the first lock surface **10451**. In some circumstances, the first lock cam **10454** may rotate about its projection **10447** in order to accommodate such movement. In any event, similar to the above, the distal movement of the distal articulation driver **10440** can articulate the end effector. Once the end effector has been sufficiently articulated, the proximal articulation driver **10430** can be released which can permit the biasing spring **10455** to displace the lock cams **10454** and **10456** into engagement with the lock surfaces **10453** and **10459**, respectively, and place the articulation lock **10450** in its locked condition, as illustrated in FIG. **119**. In order to unlock the second lock cam **10456**, referring generally to FIG. **121**, the proximal articulation driver **10430** can be pulled proximally such that a proximal drive shoulder **10436** contacts the second lock cam **10456** and pulls the second lock cam **10456** proximally. In various circumstances, the second lock cam **10456** can comprise a drive pin **10438** extending therefrom which can be contacted by the proximal drive shoulder **10436** such that, as the proximal articulation driver **10430** is pulled proximally, the second lock cam **10456** and the distal articulation driver **10440** can be slid proximally relative to the second lock surface **10459**. In some circumstances, the second lock cam **10456** may rotate about its projection **10458** in order to accommodate such movement. In any event, similar to the above, the proximal movement of the distal articulation driver **10440** can articulate the end effector in an opposite direction. Similar to the above, once the end effector has been sufficiently articulated, the proximal articulation driver **10430** can be released which can permit the biasing spring **10455** to displace the lock cams **10454** and **10456** into engagement with lock surfaces **10453** and **10459**, respectively, and place the articulation lock **10450** in its locked condition, as illustrated in FIG. **119**.

Further to the above, when a proximal load P is transmitted to the distal articulation driver **10440** from the end effector when the articulation lock **10450** is in its locked condition, the second lock cam **10456** will be further biased into engagement with the lock wall **10459**. In such circumstances, the proximal load P may only increase the wedging force holding the second lock cam **10456** in position. In effect, the second lock cam **10456** can comprise a one-way lock which can inhibit the proximal movement of the distal articulation driver **10440** until the second lock cam **10456** is unlocked, as described above. When the second lock cam **10456** is unlocked and the distal articulation driver **10440** is being moved proximally, the first lock cam **10454** may not resist, or at least substantially resist, the proximal movement of the distal articulation driver **10440**. When a distal load D is transmitted to the distal articulation driver **10440** from the end effector when the articulation lock **10450** is in its locked condition, the first lock cam **10454** will be further biased into engagement with the lock wall **10453**. In such circumstances, the distal load D may only increase the wedging force holding the first lock cam **10454** in position. In effect, the first lock cam **10454** can comprise a one-way lock which can inhibit the distal movement of the distal articulation driver **10440** until the first lock cam **10454** is unlocked, as described above. When the first lock cam **10454** is unlocked and the distal articulation driver **10440** is being moved distally, the second lock cam **10454** may not resist, or at least substantially resist, the distal movement of the distal articulation driver **10440**.

As discussed above, a surgical instrument can comprise a firing drive for treating tissue captured within an end effector of the surgical instrument, an articulation drive for articulating the end effector about an articulation joint, and a clutch assembly which can be utilized to selectively engage the articulation drive with the firing drive. An exemplary clutch assembly **10070** was discussed above while another exemplary clutch assembly, i.e., clutch assembly **11070**, is discussed below. In various circumstances, the surgical instruments disclosed herein can utilize either clutch assembly.

Turning now to FIGS. **131-149**, a surgical instrument can utilize a shaft assembly **11010** which can include an end effector **10020**, an articulation joint **10090**, and an articulation lock **10050** which can be configured to releasably hold the end effector **10020** in position. The reader will appreciate that portions of the end effector **10020** have been removed in FIGS. **131-133** for the purposes of illustration; however, the end effector **10020** can include a staple cartridge positioned therein and/or an anvil rotatably coupled to a channel supporting the staple cartridge. The operation of the end effector **10020**, the articulation joint **10090**, and the articulation lock **10050** was discussed above and is not repeated herein for sake of brevity. The shaft assembly **11010** can further include a proximal housing comprised of housing portions **11002** and **11003**, for example, which can connect the shaft assembly **11010** to a handle of a surgical instrument. The shaft assembly **11010** can further include a closure tube **11015** which can be utilized to close and/or open the anvil of the end effector **10020**. Primarily referring now to FIGS. **132-134**, the shaft assembly **11010** can include a spine **11004** which can be configured to fixably support the shaft frame portion **10012**, which is discussed above in connection with articulation lock **10050**. The spine **11004** can be configured to, one, slidably support a firing member **11060** therein and, two, slidably support the closure tube **11015** which extends around the spine **11004**. The spine **11004** can also be configured to slidably support a proximal articulation driver **11030**. In various circumstances, the spine **11004** can comprise a proximal end **11009** which is supported by a frame portion **11001** that can be configured to permit the spine **11004** to be rotated about its longitudinal axis.

Further to the above, the shaft assembly **11010** can include a clutch assembly **11070** which can be configured to selectively and releasably couple the proximal articulation driver **11030** to the firing member **11060**. The clutch assembly **11070** can comprise a lock collar, or sleeve, **11072** positioned around the firing member **11060** wherein the lock sleeve **11072** can be rotated between an engaged position in which the lock sleeve **11072** couples the proximal articulation driver **11030** to the firing member **11060** and a disengaged position in which the proximal articulation driver **11030** is not operably coupled to the firing member **11060**. When lock sleeve **11072** is in its engaged position (FIGS. **135**, **136**, **138**, **139**, **141**, and **145-149**), further to the above, distal movement of the firing member **11060** can move the proximal articulation driver **11030** distally and, correspondingly, proximal movement of the firing member **11060** can move the proximal articulation driver **11030** proximally. When lock sleeve **11072** is in its disengaged position (FIGS. **142-144**), movement of the firing member **11060** is not transmitted to the proximal articulation driver **11030** and, as a result, the firing member **11060** can move independently of the proximal articulation driver **11030**. In various circumstances, the proximal articulation driver **11030** can be held in position by the articulation lock **11050** when the proximal articulation driver **11030** is not being moved in the proximal or distal directions by the firing member **11060**.

Referring primarily to FIG. **134**, the lock sleeve **11072** can comprise a cylindrical, or an at least substantially cylindrical, body including a longitudinal aperture defined therein configured to receive the firing member **11060**. The lock sleeve **11072** can comprise a first, inwardly-facing lock member **11073** and a second, outwardly-facing lock member **11078**. The first lock member **11073** can be configured to be selectively engaged with the firing member **11060**. More particularly, when the lock sleeve **11072** is in its engaged position, the first lock member **11073** can be positioned within a drive notch **11062** defined in the firing member **11060** such that a distal pushing force and/or a proximal pulling force can be transmitted from the firing member **11060** to the lock sleeve **11072**. When the lock sleeve **11072** is in its engaged position, the second lock member **11078** can be positioned within a drive notch **11035** defined in the proximal articulation driver **11035** such that the distal pushing force and/or the proximal pulling force applied to the lock sleeve **11072** can be transmitted to the proximal articulation driver **11030**. In effect, the firing member **11060**, the lock sleeve **11072**, and the proximal articulation driver **11030** will move together when the lock sleeve **11072** is in its engaged position. On the other hand, when the lock sleeve **11072** is in its disengaged position, the first lock member **11073** may not be positioned within the drive notch **11062** of the firing member **11060** and, as a result, a distal pushing force and/or a proximal pulling force may not be transmitted from the firing member **11060** to the lock sleeve **11072**. Correspondingly, the distal pushing force and/or the proximal pulling force may not be transmitted to the proximal articulation driver **11030**. In such circumstances, the firing member **11060** can be slid proximally and/or distally relative to the lock sleeve **11072** and the proximal articulation driver **11030**. In order to accommodate such relative movement, in such circumstances, the firing member **11060** can include a longitudinal slot or groove **11061** defined therein which can be configured to receive the first lock member **11073** of the lock sleeve **11072** when the lock sleeve **11072** is in its disengaged position and, furthermore, accommodate the longitudinal movement of the firing member **11060** relative to the lock sleeve **11072**. In various circumstances, the second lock member **11078** can remain engaged with the drive notch **11035** in the proximal articulation driver **11030** regardless of whether the lock sleeve **11072** is in its engaged position or its disengaged position.

Further to the above, the clutch assembly **11070** can further comprise a rotatable lock actuator **11074** which can be configured to rotate the lock sleeve **11072** between its engaged position and its disengaged position. In various circumstances, the lock actuator **11074** can comprise a collar which can surround the lock sleeve **11072**, a longitudinal aperture extending through the collar, and referring primarily to FIG. **135**, an inwardly-extending drive element **11077** engaged with the lock sleeve **11072**. Referring again to FIG. **134**, the lock sleeve **11072** can comprise a longitudinal slot **11079** defined therein within which the drive element **11077** of the lock actuator **11074** can be received. Similar to the above, the lock actuator **11074** can be moved between an engaged position in which the lock actuator **11074** can position the lock sleeve **11072** in its engaged position and a disengaged position in which the lock actuator **11074** can position the lock sleeve **11072** in its disengaged position. In order to move the lock sleeve **11072** between its engaged position and its disengaged position, the lock actuator **11074** can be rotated about its longitudinal axis such that the drive element **11077** extending therefrom engages a sidewall of the slot **11079** to impart a rotational force to the lock sleeve **11072**. In various circumstances, the lock actuator **11074** can be constrained such that it does not move longitudinally with the lock sleeve **11072**. In such circumstances, the lock actuator **11074** may rotate within an at least partially circumferential window **11089** defined in the shaft spine **11004**. In order to accommodate the longitudinal movement of the lock sleeve **11072** when the lock sleeve **11072** is in its engaged position, the lock sleeve **11072** can further include a longitudinal opening **11079** within which the drive element **11077** can travel. In various circumstances, the longitudinal opening **11079** can include a center notch **11076** which can correspond with the unarticulated position of the end effector **10020**. In such circumstances, the center notch **11076** can serve as a detent configured to releasably hold or indicate the centered orientation of the end effector **10020**, for example.

Further to the above, referring primarily to FIG. **134**, the lock actuator **11074** can further comprise a cam follower **11081** extending outwardly therefrom which can be configured to receive a force applied thereto in order to rotate the lock sleeve **11072** as described above. In various circumstances, the shaft assembly **11010** can further comprise a switch drum **11075** which can be configured to apply a rotational force to the cam follower **11081**. The switch drum **11075** can extend around the lock actuator **11074** and include a longitudinal slot **11083** defined therein within which the cam follower **11081** can be disposed. When the switch drum **11075** is rotated, a sidewall of the slot **11083** can contact the cam follower **11081** and rotate the lock actuator **11074**, as outlined above. The switch drum **11075** can further comprise at least partially circumferential openings **11085** defined therein which, referring to FIG. **137**, can be configured to receive circumferential mounts **11007** extending from the shaft housing comprising housing halves **11002** and **11003** and permit relative rotation, but not translation, between the switch drum **11075** and the shaft housing. Referring again to FIG. **134**, the switch drum **11075** can be utilized to rotate the lock actuator **11074** and the lock sleeve **11072** between their engaged and disengage positions. In various circumstances, the shaft assembly **11010** can further comprise a biasing member, such as spring **11080**, for example, which can be configured to bias the switch drum **11075** in a direction which biases the lock actuator **11074** and the lock sleeve **11072** into their engaged positions. Thus, in essence, the spring **11080** and the switch drum **11075** can be configured to bias the articulation drive system into operative engagement with the firing drive system. As also illustrated in FIG. **134**, the switch drum **11075** can comprise portions of a slip ring assembly **11005** which can be configured to conduct electrical power to and/or from the end effector **10020** and/or communicate signals to and/or from the end effector **10020**. The slip ring assembly **11005** can comprise a plurality of concentric, or at least substantially concentric, conductors **11008** on opposing sides thereof which can be configured to permit relative rotation between the halves of the slip ring assembly **11005** while still maintaining electrically conductive pathways therebetween. U.S. patent application Ser. No. 13/800,067, entitled STAPLE CARTRIDGE TISSUE THICKNESS SENSOR SYSTEM, filed on Mar. 13, 2013, now U.S. Patent Application Publication No. 2014/0263552, is incorporated by reference in its entirety. U.S. patent application Ser. No. 13/800,025, entitled STAPLE CARTRIDGE TISSUE THICKNESS SENSOR SYSTEM, filed on Mar. 13, 2013, now U.S. Patent Application Publication No. 2014/0263551, is incorporated by reference in its entirety.

In various circumstances, further to the above, the closure mechanism of the shaft assembly **11010** can be configured to bias the clutch assembly **11070** into its disengaged state. For instance, referring primarily to FIGS. **134** and **144-147**, the closure tube **11015** can be advanced distally to close the anvil of the end effector **10020**, as discussed above and, in doing so, cam the lock actuator **11074** and, correspondingly, the lock sleeve **11072**, into their disengaged positions. To this end, the closure tube **11015** can comprise a cam window **11016**, through which the cam follower **11081** extending from the lock actuator **11074** can extend. The cam window **11016** can include an angled sidewall, or cam edge, **11017** which can be configured to engage the cam follower **11081** as the closure tube **11015** is moved distally between an open, or unclosed, position (FIGS. **145-149**) to a closed position (FIGS. **142-144**) and rotate the lock actuator **11074** from its engaged position (FIGS. **145-149**) to its disengaged position (FIGS. **142-144**). Upon comparing FIGS. **144** and **149**, the reader will appreciate that, when the cam follower **11081** and the lock actuator **11074** are cammed into their disengaged position, the cam follower **11081** can rotate the switch drum **11075** and compress the spring **11080** between the switch drum **11075** and the shaft housing. As long as the closure tube **11015** remains in its advanced, closed position, the articulation drive will be disconnected from the firing drive. In order to re-engage the articulation drive with the firing drive, the closure tube **11015** can be retracted into its unactuated position, which can also open the end effector **10020**, and can, as a result, pull the cam edge **11017** proximally and permit the spring **11080** to re-bias the lock actuator **11074** and the lock sleeve **11072** into their engaged positions.

As described elsewhere in greater detail, the surgical instrument **1010** may include several operable systems that extend, at least partially, through the shaft **1210** and are in operable engagement with the end effector **1300**. For example, the surgical instrument **1010** may include a closure assembly that may transition the end effector **1300** between an open configuration and a closed configuration, an articulation assembly that may articulate the end effector **1300** relative to the shaft **1210**, and/or a firing assembly that may fasten and/or cut tissue captured by the end effector **1300**. In addition, the surgical instrument **1010** may include a housing such as, for example, the handle **1042** which may be separably couplable to the shaft **1210** and may include complimenting closure, articulation, and/or firing drive systems that can be operably coupled to the closure, articulation, and firing assemblies, respectively, of the shaft **1210** when the handle **1042** is coupled to the shaft **1210**.

In use, an operator of the surgical instrument **1010** may desire to reset the surgical instrument **1010** and return one or more of the assemblies of the surgical instrument **1010** to a default position. For example, the operator may insert the end effector **1300** into a surgical site within a patient through an access port and may then articulate and/or close the end effector **1300** to capture tissue within the cavity. The operator may then choose to undo some or all of the previous actions and may choose to remove the surgical instrument **1010** from the cavity. The surgical instrument **1010** may include one more systems configured to facilitate a reliable return of one or more of the assemblies described above to a home state with minimal input from the operator thereby allowing the operator to remove the surgical instrument from the cavity.

Referring to FIG. **150**, the surgical instrument **1010** may include an articulation control system **3000**. A surgical operator may utilize the articulation control system **3000** to articulate the end effector **1300** relative to the shaft **1210** between an articulation home state position and an articulated position. In addition, the surgical operator may utilize the articulation control system **3000** to reset or return the articulated end effector **1300** to the articulation home state position. The articulation control system **3000** can be positioned, at least partially, in the handle **1042**. In addition, as illustrated in the exemplary schematic block diagram in FIG. **151**, the articulation control system **3000** may comprise a controller such as, for example, controller **3002** which can be configured to receive an input signal and, in response, activate a motor such as, for example, motor **1102** to cause the end effector **1300** to articulate in accordance with such an input signal. Examples of suitable controllers are described elsewhere in this document and include but are not limited to microcontroller **7004** (See FIG. **185**).

Further to the above, the end effector **1300** can be positioned in sufficient alignment with the shaft **1210** in the articulation home state position, also referred to herein as an unarticulated position such that the end effector **1300** and at least a portion of shaft **1210** can be inserted into or retracted from a patient's internal cavity through an access port such as, for example, a trocar positioned in a wall of the internal cavity without damaging the axis port. In certain embodiments, the end effector **1300** can be aligned, or at least substantially aligned, with a longitudinal axis "LL" passing through the shaft **1210** when the end effector **1300** is in the articulation home state position, as illustrated in FIG. **150**. In at least one embodiment, the articulation home state position can be at any angle up to and including 5°, for example, with the longitudinal axis on either side of the longitudinal axis. In another embodiment, the articulation home state position can be at any angle up to and including 3°, for example, with the longitudinal axis on either side of the longitudinal axis. In yet another embodiment, the articulation home state position can be at any angle up to and including 7°, for example, with the longitudinal axis on either side of the longitudinal axis.

The articulation control system **3000** can be operated to articulate the end effector **1300** relative to the shaft **1210** in a plane intersecting the longitudinal axis in a first direction such as, for example, a clockwise direction and/or a second direction opposite the first direction such as, for example, a counterclockwise direction. In at least one instance, the articulation control system **3000** can be operated to articulate the end effector **1300** in the clockwise direction form the articulation home state position to an articulated position at a 10° angle with the longitudinal axis on the right to the longitudinal axis, for example. In another example, the articulation control system **3000** can be operated to articulate the end effector **1300** in the counterclockwise direction form the articulated position at the 10° angle with the longitudinal axis to the articulation home state position. In yet another example, the articulation control system **3000** can be operated to articulate the end effector **1300** relative to the shaft **1210** in the counterclockwise direction from the articulation home state position to an articulated position at a 10° angle with the longitudinal axis on the left of the longitudinal axis. The reader will appreciate that the end effector can be articulated to different angles in the clockwise direction and/or the counterclockwise direction in response to the operator's commands.

Referring to FIG. **150**, the handle **1042** of the surgical instrument **1010** may comprise an interface **3001** which may include a plurality of inputs that can be utilized by the operator, in part, to articulate the end effector **1300** relative to the shaft **1210**, as described above. In certain embodiments, the interface **3001** may comprise a plurality of switches which can be coupled to the controller **3002** via electrical circuits, for example. In the embodiment illustrated in FIG. **151**, the interface **3001** comprises three switches **3004**A-C, wherein each of the switches **3004**A-C is coupled to the controller **3002** via one of three electrical circuits **3006**A-C, respectively. The reader will appreciate that other combinations of switches and circuits can be utilized with the interface **3001**.

Further to the above, the controller **3002** may comprise a processor **3008** and/or one or more memory units **3010**. By executing instruction code stored in the memory **3010**, the processor **3008** may control various components of the surgical instrument **1**, such as the motor **1102** and/or a user display. The controller **3002** may be implemented using integrated and/or discrete hardware elements, software elements, and/or a combination of both. Examples of integrated hardware elements may include processors, microprocessors, microcontrollers, integrated circuits, application specific integrated circuits (ASIC), programmable logic devices (PLD), digital signal processors (DSP), field programmable gate arrays (FPGA), logic gates, registers, semiconductor devices, chips, microchips, chip sets, microcontroller, system-on-chip (SoC), and/or system-in-package (SIP). Examples of discrete hardware elements may include circuits and/or circuit elements (e.g., logic gates, field effect transistors, bipolar transistors, resistors, capacitors, inductors, relay and so forth). In other embodiments, the controller **3002** may include a hybrid circuit comprising discrete and integrated circuit elements or components on one or more substrates, for example.

Referring again to FIG. **151**, the surgical instrument **1010** may include a motor controller **3005** in operable communication with the controller **3002**. The motor controller **3005** can be configured to control a direction of rotation of the motor **1102**. For example, the motor **1102** can be powered by a battery such as, for example, the battery **1104** and the motor controller **3002** may be configured to determine the voltage polarity applied to the motor **1102** by the battery **1104** and, in turn, the direction of rotation of the motor **1102** based on input from the controller **3002**. For example, the motor **1102** may reverse the direction of its rotation from a clockwise direction to a counterclockwise direction when the voltage polarity applied to the motor **1102** by the battery **1104** is reversed by the motor controller **3005** based on input from the controller **3002**. Examples of suitable motor controllers are described elsewhere in this document and include but are not limited to the driver **7010** (FIG. **185**).

In addition, as described elsewhere in this document in greater detail, the motor **1102** can be operably coupled to an articulation drive such as, for example, the proximal articulation drive **10030** (FIG. **37**). In use, the motor **1102** can drive the proximal articulation drive **10030** distally or proximally depending on the direction in which the motor **1102** rotates. Furthermore, the proximal articulation drive **10030** can be operably coupled to the end effector **1300** such that, for example, the axial translation of the proximal articulation drive **10030** proximally may cause the end effector **1300** to be articulated in the counterclockwise direction, for example, and/or the axial translation of the proximal articulation drive **10030** distally may cause the end effector **1300** to be articulated in the clockwise direction, for example.

Further to the above, referring again to FIG. **151**, the interface **3001** can be configured such that the switch **3004**A can be dedicated to clockwise articulation of the end effector **1300** and the switch **3004**B can be dedicated to counterclockwise articulation of the end effector **1300**. For example, the operator may articulate the end effector **1300** in the clockwise direction by closing the switch **3004**A which may signal the controller **3002** to cause the motor **1102** to rotate in the clockwise direction thereby, as a result, causing the proximal articulation drive **10030** to be advanced distally and causing the end effector **1300** to be articulated in the clockwise direction. In another example, the operator may articulate the end effector **1300** in the counterclockwise direction by closing the switch **3004**B which may signal the controller **3002** to cause the motor **1102** to rotate in the counterclockwise direction, for example, and retracting the proximal articulation drive **10030** proximally to articulate the end effector **1300** to in the counterclockwise direction.

Further to the above, the switches **3004**A-C can comprise open-biased dome switches, as illustrated in FIG. **154**. Other types of switches can also be employed such as, for example, capacitive switches. In the embodiment illustrated in FIG. **154**, the dome switches **3004**A and **3004**B are controlled by a rocker **3012**. Other means for controlling the switches **3004**A and **3004**B are also contemplated within the scope of the present disclosure. In the neutral position, illustrated in FIG. **154**, both of the switches **3004**A and **3004**B are biased in the open position. The operator, for example, may articulate the end effector **1300** in the clockwise direction by tilting the rocker forward thereby depressing the dome switch **3004**A, as illustrated in FIG. **155**. In result, the circuit **3006**A (FIG. **151**) may be closed signaling the controller **3002** to activate the motor **1102** to articulate the end effector **1300** in the clockwise direction, as described above. The motor **1102** may continue to articulate the end effector **1300** until the operator releases the rocker **3012** thereby allowing the dome switch **3004**A to return to the open position and the rocker **3012** to the neutral position. In some circumstances, the controller **3002** may be able to identify when the end effector **1300** has reached a predetermined maximum degree of articulation and, at such point, interrupt power to the motor **1102** regardless of whether the dome switch **3004**A is being depressed. In a way, the controller **3002** can be configured to override the operator's input and stop the motor **1102** when a maximum degree of safe articulation is reached. Alternatively, the operator may articulate the end effector **1300** in the counterclockwise direction by tilting the rocker back thereby depressing the dome switch **3004**B, for example. In result, the circuit **3006**B may be closed signaling the controller **3002** to activate the motor **1102** to articulate the end effector **1300** in the counterclockwise direction, as described above. The motor **1102** may continue to articulate the end effector **1300** until the operator releases the rocker **3012** thereby allowing the dome switch **3004**B to return to the open position and the rocker **3012** to the neutral position. In some circumstances, the controller **3002** may be able to identify when the end effector **1300** has reached a predetermined maximum degree of articulation and, at such point, interrupt power to the motor **1102** regardless of whether the dome switch **3004**B is being depressed. In a way, the controller **3002** can be configured to override the operator's input and stop the motor **1102** when a maximum degree of safe articulation is reached.

In certain embodiments, the articulation control system **3000** may include a virtual detent that may alert the operator when the end effector reaches the articulation home state position. For example, the operator may tilt the rocker **3012** to articulate the end effector **1300** from an articulated position to the articulation home state position. Upon reach the articulation home state position, the controller **3002** may stop the articulation of the end effector **1300**. In order to continue past the articulation home state position, the operator may release the rocker **3012** and then tilt it again to restart the articulation. Alternatively, a mechanical detent can also be used to provide haptic feedback for the operator that the end effect reached the articulation home state position. Other forms of feedback may be utilized such as audio feedback, for example.

Further to the above, the articulation control system **3000** may include a reset input which may reset or return the end effector **1300** to the articulation home state position if the end effector **1300** is in an articulated position. For example, as illustrated in FIG. **160**, upon receiving a reset input signal, the controller **3002** may determine the articulation position of the end effector **1300** and, if the end effector **1300** is in the articulation home state position, the controller **3002** may take no action. However, if the end effector **1300** is in an articulated position when it receives a reset input signal, the controller may activate the motor **1102** to return the end effector **1300** to the articulation home state position. As illustrated in FIG. **156**, the operator may depress the rocker **3012** downward to close the dome switches **3004**A and **3004**B simultaneously, or at least within a short time period from each other, which may transmit the reset input signal to the controller **3002** to reset or return the end effector **1300** to the articulation home state position. The operator may then release the rocker **3012** thereby allowing the rocker **3012** to return to the neutral position and the switches **3004**A and **3004**B to the open positions. Alternatively, the interface **3001** of articulation control system **3000** may include a separate reset switch such as, for example, another dome switch which can be independently closed by the operator to transmit the reset input signal to the controller **3002**.

Referring to FIGS. **157-159**, in certain embodiments, the interface **3001** of the surgical instrument **1010** may include an interface rocker **3012**A which may include a contact member **3013** which can be configured to assist the rocker **3012**A into its neutral position, as illustrated in FIG. **157**. The contact member **3013** can comprise an arcuate surface **3017** which can be biased against the interface housing **3011** by a biasing member and/or by biasing forces applied thereto by the dome switches **3004**A and **3004**B. The contact member **3013** may be configured to rock, or rotate, when the operator tilts the rocker **3012**A forward, as illustrated in FIG. **158**, or back in order to articulate the end effector **1300** in the clockwise direction or the counterclockwise direction, respectively. When the rocker **3012**A is released, the arcuate surface of the rocker **3012**A can be rotated back into its neutral position against the interface housing **3011** by the biasing forces applied thereto. In various circumstances, the contact member **3013** may be displaced away from the interface housing **3011** when the operator depresses the rocker **3012**A downwardly, as illustrated in FIG. **159**, to depress the dome switches **3004**A and **3004**B simultaneously, or at least within a short time period from each other, which may transmit the reset input signal to the controller **3002** to reset or return the end effector **1300** to the articulation home state position, as discussed above.

As described above, the controller **3002** can be configured to determine the articulation position of the end effector **1300**. Knowledge of the articulation position of the end effector **1300** may allow the controller **3002** to determine whether the motor **1102** needs to be activated to return the end effector **1300** to the articulation home state position and, if so, to determine the direction of rotation, and the amount of the rotation, of the motor **1102** required to return the end effector **1300** to the articulation home state position. In certain embodiments, the controller **3002** may track the articulation of the end effector **1300** and store the articulation position of the end effector **1300**, for example, in the memory **3010**. For example, the controller **3002** may track the direction of rotation, speed of rotation, and the time of rotation of the motor **1102** when the motor **1102** is used to articulate the end effector **1300**. In some circumstances, the controller **3002** can be configured to evaluate the displacement of the firing system when the firing system is used to drive the articulation system. More specifically, when the articulation drive is coupled to the firing drive, the controller **3002** can monitor the firing drive in order to determine the displacement of the articulation drive. The processor **3008** may calculate the articulation position of the end effector **1300** based on these parameters and store the displaced position of the articulation drive in the memory **3010**, for example. The reader will appreciate that other parameters can be tracked and other algorithms can be utilized by the processor **3010** to calculate the articulation position of the end effector **1300**, all of which are contemplated by the present disclosure. The stored articulation position of the end effector **1300** can be continuously updated as the end effector **1300** is articulated. Alternatively, the stored articulation position can be updated at discrete points, for example, when the operator releases the dome switch **3004**A or the switch **3004**B after depressing the same to articulate the end effector **1300**.

In any event, upon receiving the reset input signal, the processor **3008** may access the memory **3010** to recover the last stored articulation position of the end effector **1300**. If the last stored articulation position is not the articulation home state position, the processor **3008** may calculate the direction and time of rotation of the motor **1102** required to return the end effector **1300** to the articulation home state position based on the last stored articulation position. In some circumstances, the processor **3008** may calculate the distance and direction in which the firing drive needs to be displaced in order to place the articulation drive in its home state position. In either event, the controller **3002** may activate the motor **1102** to rotate accordingly to return the end effector **1300** to the articulation home state position. Furthermore, the processor **3008** may also update the stored articulation position to indicate articulation home state position. However, if the last stored articulation position is the articulation home state position, the controller **3002** may take no action. In some circumstances, the controller **3002** may alert the user through some form of feedback that the end effector and the articulation system is in its home state position. For example, the controller **3002** can be configured to activate a sound and/or a light signal to alert the operator that the end effector **1300** is in the articulation home state position.

In certain embodiments, the surgical instrument **1010** may include a sensor configured to detect the articulation position of the end effector **1300** and communicate the same to the controller **3002**. Similar to the above, the detected articulation position of the end effector **1300** can be stored in the memory **3010** and can be continuously updated as the end effector **1300** is articulated or can be updated when the operator releases the dome switch **3004**A or after depressing the same to articulate the end effector **1300**, for example.

In certain embodiments, it may be desirable to include a warning step prior to resetting or returning the end effector **1300** to the articulation home state position to allow an operator a chance to remedy an erroneous activation of the reset switch. For example, the controller **3002** can be configured to react to a first transmission of the reset input signal to the controller **3002** by activating a light and/or a sound signal alerting the operator that the rocker **3012** has been depressed. In addition, the controller **3002** can also be configured to react to a second transmission of the reset input signal to the controller **3002** within a predetermined time period from the first transmission by activating the motor **1102** to return the end effector **1300** to the articulation home state position. Said another way, a first downward depression of the rocker **3012** may yield a warning to the operator and a second downward depression of the rocker **3012** within a predetermined time period from the first downward depression may cause the controller **3002** to activate the motor **1102** to return the end effector **1300** to the articulation home state position.

Further to the above, the interface **3001** may include a display which can be used by the controller **3002** to communicate a warning message to the operator in response to the first downward depression of the rocker **3012**. For example, in response to the first downward depression of the rocker **3012**, the controller **3002** may prompt the operator through the display to confirm that the operator wishes to return the end effector **1300** to the articulation home state position. If the operator responds by depressing the rocker **3012** a second time within the predetermined period of time, the controller **3012** may react by activating the motor **1102** to return the end effector **1300** to the articulation home state position.

As described elsewhere in greater detail, the end effector **1300** of the surgical instrument **1010** may include a first jaw comprising an anvil such as, for example, the anvil **1310** and a second jaw comprising a channel configured to receive a staple cartridge such as, for example, the staple cartridge **1304** which may include a plurality of staples. In addition, the end effector **1300** can be transitioned between an open configuration and a closed configuration. Furthermore, the surgical instrument **1010** may include a closure lock and the handle **1042** may include a release member for the closure lock such as, for example, the release member **1072** which can be depressed by the operator to release the closure lock thereby returning the end effector **1300** to the open configuration. In addition, the controller **3002** can be coupled to a sensor **3014** configured to detect the release of the closure lock by the release member **1272**. Furthermore, the surgical instrument **1010** may include a firing drive such as, for example, the firing drive **1110** which can be operably coupled to a firing member such as, for example, the firing member **10060**. The controller **3002** can be coupled to a sensor **3015** configured to detect the position of the firing drive **1110**. The firing drive **1110** can be moved axially to advance the firing member **10060** from a firing home state position to a fired position to deploy the staples from the staple cartridge **1304** and/or cut tissue captured between the anvil **1310** and the staple cartridge **1304** when the end effector **1300** is in the closed configuration.

Also, as described elsewhere in greater detail, the proximal articulation drive **10030** of the surgical instrument **1010** can be selectively coupled with the firing drive **1110** such that, when the firing drive **1110** is motivated by the motor **1102**, the proximal articulation drive **10030** can be driven by the firing drive **1110** and the proximal articulation drive **10030** can, in turn, articulate the end effector **1300** relative to the shaft **1210**, as described above. Furthermore, the firing drive **1110** can be decoupled from the proximal articulation drive **10030** when the end effector **1300** is in the closed configuration. This arrangement permits the motor **1102** to motivate the firing drive **1110** to move the firing member **10060** between the firing home state position and the fired position independent of the proximal articulation drive **10030**.

Further to the above, as described else wherein in greater detail, the surgical instrument **1010** can include a clutch system **10070** (See FIG. **37**) which can be engaged when the end effector **1300** is transitioned from the open configuration to the closed configuration and disengaged when the end effector **1300** is transitioned from the closed configuration to the open configuration. When engaged, the clutch system **10070** may operably couple the firing drive **1110** to the proximal drive member **10030** and when the clutch member is disengaged, the firing drive **1110** may be decoupled from the proximal articulation drive. Since the firing drive **1110** can be decoupled and moved independently from the proximal articulation drive **10030**, the controller **3002** may be configured to guide the firing drive **1110** to locate the proximal articulation drive **10030** and re-couple the proximal articulation drive **10030** to the firing drive **1110** once again. The controller **3002** may track the direction of rotation, speed of rotation and the time of rotation of the motor **1102** when the firing drive **1110** is coupled to the proximal articulation drive **10030** to determine and store the location of the proximal articulation drive **10030**, for example, in memory **3010**. The controller **3002** may, as described elsewhere herein, monitor the displacement of the firing system used to drive the articulation system. Other parameters and algorithms can be utilized to determine the location of the proximal articulation drive **10030**. In certain embodiments, the firing drive **1110** may include a sensor configured to detect when the firing drive **1110** is coupled to the proximal articulation drive **10030** and communicate the same to the controller **3002** to confirm the coupling engagement between the firing drive **1110** and the proximal articulation drive **10030**. In certain embodiments, when the controller **3002** is not configured to store and access the articulation position of the end effector **1300**, the controller may activate the motor **1102** to motivate the firing drive **1110** to travel along its full range of motion until the firing drive **1110** comes into coupling arrangement with the proximal articulation drive **10030**.

Further to the above, in certain embodiments, the firing home state position of the firing member **10060** can be located at a proximal portion of the end effector **1300**. Alternatively, the firing home state position of the firing member **10060** can be located at a distal portion of the end effector **1300**. In certain embodiments, the firing home state position may be defined at a position where the firing member **10060** is sufficiently retracted relative to the end effector **1300** such that the end effector **1300** can be freely moved between the open configuration and the closed configuration. In other circumstances, the firing home state position of the firing member **10060** can be identified as the position of the firing member which positions the articulation drive system and the end effector in its articulated home state position.

Referring again to FIG. **151**, the interface **3001** of the surgical instrument **1010** may include a home state input. The operator may utilize the home state input to transmit a home state input signal to the controller **3002** to return the surgical instrument **1010** to home state which may include returning the end effector **1300** to the articulation home state position and/or the firing member **10060** to the firing home state position. As illustrated in FIG. **154**, the home state input may include a switch such as, for example, the switch **3004**C which can be coupled to the controller **3002** via an electrical circuit **3006**C. As illustrated in FIGS. **152** and **153**, the home state input may include a cap or a cover such as, for example, cover **3014** which can be depressed by the operator to close the switch **3004**C and transmit the home state input signal through the circuit **3006**C to the controller **3002**.

Referring again to FIG. **161**, the controller **3002**, upon receiving the home state input signal, may check the position of the firing drive **1110** through the sensor **3015** and may check the memory **3010** for the last updated articulation position. If the controller **3002** determines that the end effector **1300** is in the articulation home state position and the firing drive **1110** is positioned such that it is coupled to the proximal articulation drive **10030**, the controller **3002** may take no action. Alternatively, the controller **3002** may provide feedback to the operator that the surgical instrument **1010** is at home state. For example, the controller **3002** can be configured to activate a sound and/or a light signal or transmit a message through the display to alert the operator that the surgical instrument **1010** is at home state. However, if the controller **3002** determines that the end effector **1300** is not in the articulation home state position and the firing drive **1110** is positioned such that it is coupled to the proximal articulation drive **10030**, the controller **3002** may activate the motor **1102** to motivate the firing drive **1110** to move the proximal articulation drive **10030** which can, in turn, articulate the end effector **1300** relative to the shaft **1210** back to the articulation home state position. Alternatively, if the controller **3002** determines that the end effector **1300** is in the articulation home state position but the firing drive **1110** is not positioned such that it is coupled to the proximal articulation drive **10030**, the controller **3002** may activate the motor **1102** to move the firing drive **1110** to a position wherein the firing drive **1110** is coupled to the articulation drive **10030**. In doing so, the motor **1102** may retract the firing member **10060** to the firing home state position.

In certain embodiments, referring to FIG. **162**, the controller **3002**, upon receiving the home state input signal, may check whether the end effector **1300** is in the open configuration through the sensor **3016**. Other means for determining whether the end effector **1300** is in the open configuration can be employed. If the controller **3002** determines that the end effector **1300** is in the open configuration, the controller **3002** may proceed as described above. However, if the controller **3002**, upon receiving the home state input signal, determines that the end effector **1300** is in the closed configuration, the controller **3002** may prompt the operator to confirm that the operator wishes to return the surgical instrument **1010** to home state. This step can be a precautionary step to prevent the operator from accidentally opening the end effector **1300** during a surgical procedure, for example. In certain embodiments, the controller **3002** may prompt the operator by displaying a message on a display coupled to the controller **3002**, for example, requesting the operator to return the end effector **1300** to the open configuration by depressing the release member **1072**. If the operator does not release the end effector **1300** to the open configuration, the controller **3002** may take no action. In other embodiments, the controller **3002** may alert the operator by displaying an error message or activating a sound or a light. However, if the operator releases the end effector **1300** to the open configuration, the controller **3002** may reset the surgical instrument as described above.

Referring to FIG. **163**, the firing member **10060** may comprise a separate firing reset input which may include a switch and an electrical circuit coupling the switch to controller **3002**, wherein the switch can be configured to close the circuit and transmit a firing reset input signal to the controller **3002**. The controller **3002**, upon receiving the firing reset input signal may check whether the firing member **10060** is in the firing home state position. As described elsewhere in greater detail, the firing member **10060** may be operably coupled to the firing drive **1110** which may comprise a sensor such as, for example, sensor **3015** (See FIG. **151**) that may transmit the location of the firing drive **1110** to the controller **3002**. Accordingly, the controller **3002** can determine the location of the firing member **10060** by monitoring the location of the firing drive **1110**. In any event, if the controller **3002** determines that the firing member **10060** is in the firing home state position, the controller may take no action or may alert the operator that the firing member **10060** is already in the firing home state position by activating a sound and/or a light. On the hand, if the controller **3002** determines that the firing member **10060** is not in the firing home state position, the controller **3002** may activate the motor **1102** to motivate the firing drive **1110** to return the firing member **10060** to the firing home state position.

As described elsewhere in greater detail, the surgical instrument **1010** may include several assemblies that extend, at least partially, through the shaft **1210** and may be in operable engagement with the end effector **1300**. For example, the surgical instrument **1010** may include a closure assembly that may transition the end effector **1300** between an open configuration and a closed configuration, an articulation assembly that may articulate the end effector **1300** relative to the shaft **1210**, and/or a firing assembly that may fasten and/or cut tissue captured by the end effector **1300**. In addition, the surgical instrument **1010** may include a housing such as, for example, the handle **1042** which may be separably couplable to the shaft **1210** and may include complimenting closure, articulation, and/or firing drive systems that can be operably coupled to the closure, articulation, and/or firing assemblies, respectively, of the shaft **1210** when the handle **1042** is coupled to the shaft **1210**.

In use, the assemblies described above and their corresponding drive systems may be operably connected. Attempting to separate the handle **1042** from the shaft **1210** during operation of the surgical instrument **1010** may sever the connections between the assemblies and their corresponding drive systems in a manner that may cause one or more of these assemblies and their corresponding drive systems to be out of alignment. On the other hand, preventing the user from separating the handle **1042** from the shaft **1210** during operation, without more, may lead to confusion, frustration, and/or an erroneous assumption that the surgical instrument is not operating properly.

The surgical instrument **1010** may include a safe release system **3080** that may be configured to return one or more of the assemblies and/or corresponding drive systems of the surgical instrument **1010** to a home state thereby allowing the operator to safely separate the handle **1042** from the shaft **1210**. The term home state as used herein may refer to a default state wherein one or more of the assemblies and/or corresponding drive systems of the surgical instrument **1010** may reside or may be returned to their default position such as, for example, their position prior to coupling the handle **1042** with the shaft **1210**.

Referring to FIG. **150**, the safe release system **3080** of the surgical instrument **1010** may include a locking member such as, for example, locking member **3082** which can be moved between a locked configuration and an unlocked configuration. As illustrated in FIG. **164** and as described elsewhere in greater detail, the shaft **1210** may be aligned and coupled with the handle **1042** of the surgical instrument **1010**. In addition, the locking member **3082** may be moved from the unlocked configuration to the locked configuration to lock the handle in coupling engagement with the shaft **1210**. The locking member **3082** can be positioned at a proximal portion of the shaft **1210**, as illustrated in FIG. **166** and may include a latch member **3083** that can be advanced into a receiving slot **3085** positioned in the handle **1042** when the locking member **3082** is moved to the locked configuration and the handle **1042** is coupled to the shaft **1210**. In addition, the latch member **3083** can be retracted out of the receiving slot **3085** when the locking member **3082** is moved to the unlocked configuration thereby allowing the handle **1042** to be separated from the shaft **1210**, as illustrated in FIG. **167**.

Referring to FIG. **151**, the safe release system **3080** may further include an interlock switch **3084** which can be coupled to the controller **3002** via an electric circuit **3086** which can be configured to transmit a home state input signal to the controller **3002**. In addition, the interlock switch **3084** may be operably coupled to the locking member **3082**. For example, the switch **3086** can be moved to close the circuit **3086** when the locking member is moved to the unlocked configuration, as illustrated in FIG. **167** and can be moved to open the circuit **3086** when the locking member **3082** is moved to the locked configuration, as illustrated in FIG. **166**. In this example, the controller **3002** can be configured to recognize the closing of the circuit **3086** as a transmission of the home state input signal. Alternatively, in another example, the switch **3086** can be moved to open the circuit **3086** when the locking member is moved to the unlocked configuration and can be moved to close the circuit **3086** when the locking member **3082** is moved to the locked configuration. In this example, the controller **3002** can be configured to recognize the opening of the circuit **3086** as a transmission of the home state input signal.

Referring again to FIG. **166** and FIG. **167**, the locking member **3082** may include a first surface **3090** and a second surface **3092** which can be separated by a ramp **3094**, wherein the locking member **3082** can be positioned relative to the switch **3084** such that the first surface **3090** and the second **3092** may be slidably movable relative to the switch **3084** when the handle **1042** is coupled to the shaft **1210**. Furthermore, as illustrated in FIG. **166**, the first surface **3090** may extend in a first plane and the second surface **3092** may extend in a second plane, wherein the switch **3084** can be closer to the first plane that the second plane. Furthermore, as illustrated in FIG. **166**, the switch **3084** may be depressed by the first surface **3090** when the locking member **3082** is in the locked configuration and the latch member **3083** is received within the receiving slot **3085**, thereby closing the circuit **3086** (FIG. **151**) and transmitting the home state input signal to the controller **3002**. However, as the locking member **3082** is moved to the unlocked configuration and the latch member **3083** is retracted from the receiving slot **3085**, the switch **3084** may slide along the ramp **3094** to face the second surface **3092** which may provide the biased switch **3084** with sufficient room to return to the open position, as illustrated in FIG. **166**.

In certain embodiments, as illustrated in FIGS. **151** and **165**, a first end **3084***a* of the switch **3084** can be positioned in the handle **1042**, for example, at a distal portion thereof and a second end **3084***b* of the switch **3084** can be positioned in the shaft **1210**, for example, at a proximal portion thereof and can be operably coupled with the locking member **3082**. In these embodiments, the switch **3084** may not close the circuit **3086** until the handle **1042** is coupled to the shaft **1210** to permit the locking member **3082** to bring the second end **3084***b* of the switch **3084** into contact with the first end **3084***a* thereby closing the circuit **3086** and transmitting the home state input signal to the controller **3002**. In other embodiments, the locking member **3082**, the first end **3084***a*, and the second end **3084***b* of the switch **3084** can be placed in the handle **1042** to permit closure of the circuit **3086** and transmission of the home state input signal to the controller **3002** prior to coupling the handle **1042**, for example, to return the firing drive system to its default position to ensure proper alignment with the firing assembly when the shaft **1210** is coupled to the handle **1042**.

As described elsewhere in greater detail, the end effector **1300** of the surgical instrument **1010** may include a first jaw comprising an anvil such as, for example, the anvil **1310** and a second jaw comprising a channel configured to receive a staple cartridge such as, for example, the staple cartridge **1304** which may include a plurality of staples. In addition, the end effector **1300** can be transitioned between an open configuration and a closed configuration. For example, the surgical instrument **1010** may include a closure lock for locking the end effector **1300** in a closed configuration and the handle **1042** may include a release member for the closure lock such as, for example, the release member **1072** which can be depressed by the operator to release the closure lock thereby returning the end effector **1300** to the open configuration. In addition, the controller **3002** can be coupled to a sensor **3014** configured to detect the release of the closure lock by the release member **1072**. Furthermore, the surgical instrument **1010** may include a firing drive such as, for example, the firing drive **1110** which can be operably coupled to a firing member such as, for example, the firing member **10060**. The controller **3002** can be coupled to a sensor **3015** configured to detect the position of the firing drive **1110**. In addition, the firing drive **1110** can be advanced axially, as illustrated in FIG. **167**A, to advance the firing member **10060** between an unfired position and a fired position to deploy the staples of the staple cartridge **1304** and/or cut tissue captured between the anvil **1310** and the staple cartridge **1304** when the end effector **1300** is in the closed configuration. Furthermore, the firing drive can be retracted by the motor **1102** from the advanced position, for example, the position illustrated in FIG. **167**A to a default or retracted position as illustrated in FIG. **167**B when the locking member **3082** is moved from the closed configuration to the open configuration.

Further to the above, as described elsewhere in greater detail, the proximal articulation drive **10030** of the surgical instrument **1010** can be selectively coupled with the firing drive **1110** such that, when the firing drive **1110** is motivated by the motor **5**, the proximal articulation drive **10030** can be driven by the firing drive **1110** and the proximal articulation drive **10030** can, in turn, articulate the end effector **1300** relative to the shaft **1210** between the articulation home state position and the articulate position, as described above. Furthermore, the firing drive **1110** can be decoupled from the proximal articulation drive **10030**, for example, when the end effector **1300** is in the closed configuration. This arrangement permits the motor **1102** to motivate the firing drive **1110** to move the firing member **10060** between the unfired position and the fired position independent of the proximal articulation drive **10030**. Since the firing drive **1110** can be decoupled from and moved independently from the proximal articulation drive **10030**, the controller **3002** may be configured to guide the firing drive **1110** to locate and reconnect with the proximal articulation drive **10030**. In a way, the controller **3002** can remember where it left the proximal articulation drive **10030**. More particularly, the controller **3002** can, one, evaluate the position of the firing drive **1110** when the proximal articulation drive **10030** is decoupled from the firing drive **1110** and, two, remember where the proximal articulation drive **10030** is when the controller **3002** is instructed to reconnect the firing drive **1110** with the proximal articulation drive **10030**. In such circumstances, the controller **3002** can move the firing drive **1110** into a position in which the clutch assembly **10070**, for example, can reconnect the proximal articulation drive **10030** to the firing drive **1110**. The controller **3002** may track the direction of rotation, speed of rotation and the time of rotation of the motor **1102** when the firing drive **1110** is coupled to the proximal articulation drive **10030** to determine and store the location of the proximal articulation drive **10030**, for example, in the memory **3010**. Other parameters and algorithms can be utilized to determine the location of the proximal articulation drive **10030**. In certain embodiments, the firing drive **1110** may include a sensor configured to detect when the firing drive **1110** is coupled to the proximal articulation drive **10030** and communicate the same to the controller **3002** to confirm the coupling engagement between the firing drive **1110** and the proximal articulation drive **10030**. In certain embodiments, when the controller **3002** is not configured to store and access the proximal articulation drive **10030**, the controller may activate the motor **1102** to motivate the firing drive **1110** to travel along its full range of motion until the firing drive **1110** comes into coupling arrangement with the proximal articulation drive **10030**.

Referring now to FIGS. **151** and **165**, the safe release system **3080** may react to an operator's attempt to separate the handle **1042** from the shaft **1210** by resetting the surgical instrument **1010** to the home state, for example, as soon as the operator moves the locking member **3082** from the locked configuration to the unlocked configuration. As described above, the switch **3084** can be operably coupled to the locking member **3082** such that when the locking member **3082** is moved from the locked configuration to the unlocked configuration, the switch **3084** may be moved to open the circuit **3086** thereby transmitting the home state input signal to the controller **3002**. Alternatively, movement of the switch **3084** from its locked configuration to its unlocked configuration may allow the circuit **3086** to close thereby transmitting the home state input signal to the controller **3002**.

Referring again to FIG. **168**, the controller **3002**, upon receiving the home state input signal, may check the position of the firing drive **1110** through the sensor **3015** and may check the memory **3010** for the last updated articulation position of the end effector and, correspondingly, the last position of the proximal articulation drive **10030**. If the controller **3002** determines that the end effector **1300** is in the articulation home state position and the firing drive **1110** is positioned such that it is coupled to the proximal articulation drive **10030**, the controller **3002** may take no action and the user may remove the shaft assembly from the handle. Alternatively, the controller **3002** may provide feedback to the operator that the surgical instrument **1010** is at home state and/or it is safe to separate the handle **1042** from the shaft **1210**. For example, the controller **3002** can be configured to activate a sound and/or a light signal and/or transmit a message through a display (not shown) coupled to the controller **3002** to alert the operator that the surgical instrument **1010** is at home state and/or it is safe to separate the handle **1042** from the shaft **1210**. However, if the controller **3002** determines that the end effector **1300** is not in the articulation home state position and the firing drive **1110** is positioned such that it is coupled to the proximal articulation drive **10030**, the controller **3002** may activate the motor **1102** to motivate the firing drive **1110** to move the proximal articulation drive **10030** which can, in turn, articulate the end effector **1300** relative to the shaft **1210** back to the articulation home state position. Alternatively, if the controller **3002** determines that the end effector **1300** is in the articulation home state position but the firing drive **1110** is not positioned such that it is coupled to the proximal articulation drive **10030**, the controller **3002** may activate the motor **1102** to move the firing drive **1110** to a position wherein the firing drive **1110** is couplable to the articulation drive **9**. In doing so, the firing member **9** may retract the firing member **10060** to the firing home state position. As described above, the controller **3002** may optionally provide the feedback to the operator that the surgical instrument **1010** is at home state and that it is safe to separate the handle **1042** from the shaft **1210**.

In certain embodiments, referring to FIG. **169**, the controller **3002**, upon receiving the home state input signal, may check whether the end effector **1300** is in the open configuration through the sensor **3016**. Other means for determining that the end effector **1300** is in the open configuration can be employed. If the controller **3002** determines that the end effector **1300** is in the open configuration, the controller **3002** may proceed to reset the surgical instrument **1010** to home state, as described above. However, if the controller **3002**, upon receiving the home state input signal, determines that the end effector **1300** is in the closed configuration, the controller **3002** may prompt the operator to confirm that the operator wishes to separate the handle **1042** from the shaft **1210**. This step can be a precautionary step to prevent resetting the surgical instrument **1010** if the operator accidentally moved the locking member **3082** thereby erroneously transmitting a home state input signal to the controller **3002** while the end effector **1300** is in use and clamping tissue, for example. In certain embodiments, the controller **3002** may prompt the operator by displaying a message on the display coupled to the controller **3002**, for example, requesting the operator to return the end effector **1300** to the open configuration by depressing the release member **1072**. In addition to the mechanical locking member **3082**, the safe release system **3080** may also include an electronic lock (not shown) which may be controlled by the controller **3002**. The electronic lock can be configured to prevent the operator from separating the handle **1042** and the shaft **1210** until the operator depresses the release member **1072**. If the operator does not release the end effector **1300** to the open configuration, the controller **3002** may take no action. In other embodiments, the controller **3002** may alert the operator by displaying an error message or activating a sound and/or a light signal. On the other hand, if the operator releases the end effector **1300** to the open configuration, the controller **3002** may reset the surgical instrument **1010** as described above. If an electronic lock is used, the controller **3002** may then release the electronic lock to permit the operator to separate the handle **1042** from the shaft **1210**. In addition, the controller **3002** may then alert the operator that it is now safe to remove the handle **1042** from the shaft **1210**, as described above.

In certain embodiments, it may be desirable to include a warning step prior to resetting the surgical instrument **1010** to home state in response to the home state input signal to provide an operator with a chance to remedy an accidental unlocking of the locking member **3082**. For example, the controller **3002** can be configured to react to a first transmission of the home state input signal by asking the operator to confirm that the operator wishes to reset the surgical instrument **1010**, for example, through the display. In certain embodiments, the operator may transmit a second home state input signal to the controller **3002** within a predetermined time period from the first home state input signal by locking and unlocking the locking member **3082** a second time. The controller **3002** can be configured to react to the second transmission of the home state input signal if transmitted within the predetermined time period from the first transmission by resetting the surgical instrument **1010** to the home state, as described above.

An electric motor for a surgical instrument described herein can perform multiple functions. For example, a multi-function electric motor can advance and retract a firing element during a firing sequence. To perform multiple functions, the multi-function electric motor can switch between different operating states. The electric motor can perform a first function in a first operating state, for example, and can subsequently switch to a second operating state to perform a second function, for example. In various circumstances, the electric motor can drive the firing element distally during the first operating state, e.g., an advancing state, and can retract the firing element proximally during the second operating state, e.g., a retracting state. In certain circumstances, the electric motor can rotate in a first direction during the first operating state and can rotate in second direction during the second operating state. For example, clockwise rotation of the electric motor can advance the firing element distally and counterclockwise rotation of the electric motor can retract the firing element proximally. The electric motor can be balanced or substantially balanced during the first and second operating states such that background haptic feedback or "noise" generated by the electric motor is minimized. Though the haptic feedback can be minimized during the first and second operating states, it may not be entirely eliminated in certain circumstances. In fact, such "noise" may be expected by the operator during normal operation of the surgical instrument and, as such, may not constitute a feedback signal indicative of a particular condition of the surgical instrument.

In various circumstances, the multi-function electric motor can perform additional functions during additional operating states. For example, during a third operating state, e.g., a feedback state, the electric motor can generate amplified haptic or tactile feedback in order to communicate a particular condition of the surgical instrument to the operator thereof. In other words, a multi-function electric motor can drive a firing element distally and proximally during a firing sequence, e.g., the first operating state and the second operating state, respectively, and can also generate the amplified haptic feedback to communicate with the operator of the surgical instrument, e.g., during the third operating state. The amplified haptic feedback generated during the third operating state can substantially exceed the background haptic feedback or "noise" generated during the first and second operating states. In various embodiments, the amplified haptic feedback generated during the third operating state can constitute a feedback signal to the operator that is indicative of a particular condition of the surgical instrument. For example, the electric motor can generate the amplified haptic feedback when a predetermined threshold force is detected on the firing element. In such embodiments, the amplified haptic feedback can constitute a warning signal to the operator such as, for example, a potential overload warning. In other embodiments, the amplified haptic feedback can communicate a status update to the operator such as, for example, a signal that the firing element has reached a distal-most position and/or successfully completed a firing stroke. In various embodiments, the electric motor can oscillate between clockwise rotation and counterclockwise rotation during the third operating state. As described herein, a resonator or amplifier mounted to the electric motor can oscillate with the electric motor to optimize or amplify the haptic feedback generated by the electric motor. Though the resonator can amplify haptic feedback during the third operating state, the resonator can be balanced relative to its axis of rotation, for example, such that the background haptic feedback or "noise" remains minimized during the first and second operating states.

In various circumstances, the multi-function electric motor can switch between different operating states. For example, the electric motor can switch from the first operating state to the second operating state in order to retract the firing element from a distal position in an end effector. Furthermore, the electric motor can switch to the third operating state to communicate a signal indicative of a particular condition of the surgical instrument to the operator. For example, when a clinically-important condition is detected, the electric motor can switch from the first operating state to the third operating state in order to communicate the clinically-important condition to the operator. In certain embodiments, the electric motor can generate amplified haptic feedback to communicate the clinically-important condition to the operator. When the electric motor switches to the third operating state, the advancement of the firing element can be paused. In various embodiments, upon receiving the amplified haptic feedback, the operator can decide whether (A) to resume the first operating state, or (B) to initiate the second operating state. For example, where the clinically-important condition is a high force on the firing element, which may be indicative of potential instrument overload, the operator can decide (A) to resume advancing the firing element distally, or (B) to heed the potential overload warning and retract the firing element proximally. If the operator decides to resume the first operating state despite the potential for instrument overload, the instrument may be at risk of failure. In various embodiments, a different electric motor can generate feedback to communicate the clinically-important condition to the operator. For example, a second electric motor can generate sensory feedback such as a noise, a light, and/or a tactile signal, for example, to communicate the clinically-important condition to the operator.

Referring now to FIG. **170**, an electric motor **5002** for a surgical instrument (illustrated elsewhere) can comprise a motor housing **5004** and a shaft **5006** extending from the motor housing **5004**. While electric motor **5002** is described herein as one example, other electric motors, such as motor **1102**, for example, can incorporate the teachings disclosed herein. The shaft **5006** can be fixed to a rotor (not illustrated) positioned within the motor housing **5004**, and the shaft **5006** can rotate as the rotor rotates. The shaft **5006** can rotate in one direction during a first operating state, for example, and can rotate in a second direction during the second operating state, for example. Furthermore, the rotation of the electric motor **5002** in one direction can implement a first surgical function, and the rotation of the electric motor **5002** in another direction can implement a second surgical function. In various embodiments, the electric motor **5002** and/or the shaft **5006** thereof can be operably coupled to a firing element (illustrated elsewhere), and can drive the firing element during a firing sequence. For example, clockwise rotation of the electric motor **5002** can drive the firing element distally, and counterclockwise rotation of the electric motor **5002** can drive the firing element proximally. Alternatively, counterclockwise rotation of the electric motor **5002** can drive the firing element distally, and clockwise rotation of the electric motor **5002** can drive the firing element proximally. In other words, the electric motor can advance the firing element during the first operating state and can retract the firing element during the second operating state, or vice versa. In other embodiments, the electric motor **5002** can be operably coupled to an articulation mechanism (illustrated elsewhere), and can articulate an end effector relative to a handle of the surgical instrument. For example, clockwise rotation of the electric motor **5002** can articulate the end effector in a first direction, and counterclockwise rotation of the electric motor **5002** can articulate the end effector in a second direction.

In various embodiments, a resonator or amplifier **5020** can be mounted on the shaft **5006** of the electric motor **5002**. A washer **5008** can secure the resonator **5020** relative to the shaft **5006**, for example. Furthermore, the resonator **5020** can be fixedly secured to the shaft **5006** such that the resonator **5020** rotates and/or moves with the shaft **5006**. In various embodiments, the resonator **5020** and/or various portions thereof can be fastened to the shaft **5006** and/or can be integrally formed therewith, for example.

Referring now to FIGS. **170-172**, the resonator **5020** can comprise a body **5022** comprising a mounting bore **5040** (FIGS. **171** and **172**) for receiving the shaft **5006** (FIG. **170**). For example, the shaft **5006** can extend through the mounting bore **5040** when the resonator **5020** is secured to the shaft **5006**. The mounting bore **5040** and the shaft **5006** can be coaxial, for example. In various embodiments, the body **5022** of the resonator **5020** can be balanced and/or symmetrical relative to the mounting bore **5040**, and the center of mass of the body **5022** can be positioned along the central axis of the mounting bore **5040**, for example. In such embodiments, the center of mass of the body **5022** can be positioned along the axis of rotation of the shaft **5006**, and the body **5022** can be balanced relative to the shaft **5006**, for example.

In various circumstances, the resonator **5020** can further comprise a pendulum **5030** extending from the body **5022**. For example, the pendulum **5030** can comprise a spring or bar **5032** extending from the body **5022** and a weight **5034** extending from the spring **5032**. In certain circumstances, the resonator **5020** and/or the pendulum **5030** thereof can be designed to have an optimized natural frequency. As described herein, an optimized natural frequency can amplify the haptic feedback generated when the electric motor **5002** oscillates between clockwise and counterclockwise rotations, e.g., during the third operating state. In various circumstances, the resonator **5020** can further comprise a counterweight **5024** extending from the body **5022**. Referring primarily to FIG. **172**, the pendulum **5030** can extend from the body **5022** in a first direction X, and the counterweight **5024** can extend from the body **5022** in a second direction Y. The second direction Y can be different than and/or opposite to the first direction X, for example. In various embodiments, the counterweight **5024** can be designed to balance the mass of the pendulum **5030** relative to the mounting bore **5040** (FIGS. **171** and **172**) through the body **5022**. For example, the geometry and material of the counterweight **5024** can be selected such that the center of mass **5028** (FIG. **172**) of the entire resonator **5020** is positioned along the central axis of the mounting bore **5040** of the body **5022**, and thus, along the axis of rotation of the resonator **5020** and the shaft **5006** (FIG. **170**).

The center of mass **5028** of the resonator **5020** ($CM_R$) can be determined from the following relationship:

$$CM_R = \frac{1}{m_R}(CM_B \cdot m_B + CM_C \cdot m_C + CM_S \cdot m_S + CM_W \cdot m_W),$$

where $m_R$ is the total mass of the resonator **5020**, $CM_B$ is the center of mass of the body **5022**, $CM_C$ is the center of mass of the counterweight **5024**, $CM_S$ is the center of mass of the spring **5032**, $CM_W$ is the center of mass of the weight **5034**, $m_B$ is the mass of the body **5022**, $m_C$ is the mass of the counterweight **5024**, $m_S$ is the mass of the spring **5032**, and $m_W$ is the mass of the weight **5034**. Where the center of mass of the body **5022** is positioned along the central axis of the mounting bore **5040** and the resonator **5020** comprises a uniform thickness and uniform density, the resonator **5020** can be balanced relative to the central axis of the mounting bore **5040** according to the following simplified relationship:

$$A_C \cdot CM_C = A_S \cdot CM_S + A_W \cdot CM_W,$$

wherein $A_C$ is the area of the counterweight **5024**, $A_S$ is the area of the spring **5032**, and $A_W$ is the area of the weight **5034**.

In various circumstances, when the center of mass **5028** of the resonator **5020** is centered along the central axis of the mounting hole **5040**, and thus, along the axis of rotation of the shaft **5006** (FIG. **170**), the resonator **5020** can be balanced relative to its axis of rotation thereof. In such embodiments, because the resonator **5020** is balanced, the background haptic feedback can be minimized during the first and second operating states. In various circumstances, the resonator **5020** can include additional or fewer components. The various components of the resonator **5020** can be balanced such that the center of mass **5028** of the entire resonator **5020** is balanced relative to the axis of rotation of the resonator **5020**. Additionally, in some embodiments, the material and/or density of various components of the resonator **5020** can differ from various other components of the resonator **5020**. The material and/or density of the various components can be selected to balance the mass of the resonator **5020** relative to the axis of rotation and/or to optimize the natural frequency of the resonator **5020** and/or the pendulum **5030** thereof, as described herein.

Referring still to FIGS. **170-172**, the spring **5032** of the pendulum **5030** can be deflectable and/or deformable. For example, rotation of the resonator **5020** can cause the spring **5032** of the pendulum **5030** to deflect. The spring **5032** can deflect upon initial rotation of the resonator **5020**, and can remain deflected as the resonator **5020** continues to rotate in the same direction and at the same rotational speed. Because the deflection of the spring **5032** remains at least substantially constant during continued substantially constant rotation of the resonator **5020** in one direction, the background haptic feedback can remain minimized during the first and second operating states. When the rotational direction of the resonator **5020** changes, the spring **5032** can deflect in a different direction. For example, the spring **5032** can deflect in a first direction when the resonator **5020** rotates clockwise and can deflect in a second direction when the resonator **5020** rotates counterclockwise. The second direction can be opposite to the first direction, for example. In other words, as the electric motor **5020** oscillates between clockwise rotation and counterclockwise rotation, the spring **5032** can repeatedly deflect in different directions in response to the changes in the direction of rotation. Repeated deflections of the spring **5032** in opposite directions, i.e., deflective oscillations, can generate the amplified haptic feedback. For example, the haptic feedback generated by the oscillating resonator **5020**, which is driven by the oscillating motor **5002** (FIG. **170**), can be sufficiently amplified such that it provides a signal to the operator indicative of a particular condition of the surgical instrument. The amplified haptic feedback generated by the oscillating resonator **5020** and motor **5002** can be substantially greater than the background haptic feedback generated during the sustained rotation of the resonator **5020** and motor **5002** in the same direction.

In use, the rotation of the pendulum **5030** can generate a centrifugal force on the weight **5034**, and the spring **5032** of the pendulum **5030** can elongate in response to the centrifugal force. In various embodiments, the resonator **5020** and/or the motor **5002** can comprise a retainer for limiting radial elongation of the spring **5032**. Such a retainer can retain the pendulum **5030** within a predefined radial boundary **5050** (FIG. **170**). In various circumstances, the centrifugal force exerted on the weight **5034** during the third operating state may be insufficient to elongate the pendulum **5030** beyond the redefined radial boundary **5050**.

In various circumstances, the resonator **5020** can be designed to amplify the haptic feedback generated by the electric motor **5002** (FIG. **170**) during the third operating state. In other words, the resonator **5020** can be designed such that the natural frequency of the resonator **5020** is optimized, and the electric motor **5002** can oscillate at a frequency that drives the resonator **5020** to oscillate at its optimized natural frequency. In various embodiments, the optimized natural frequency of the resonator **5020** can be related to the frequency of oscillations of the electric motor **5002**. The optimized natural frequency of the resonator **5020** can coincide with and/or correspond to the oscillation frequency of the electric motor **5002**, for example. In certain embodiments, the optimized natural frequency of the resonator **5020** can be offset from the oscillation frequency of the electric motor **5002**, for example.

In certain embodiments, the natural frequency of the resonator **5020** can be approximated by the natural frequency of the pendulum **5030**. For example, substantially non-oscillating components can be ignored in the natural frequency approximation. In certain embodiments, the body **5022** and the counterweight **5024** can be assumed to be substantially non-oscillating components of the resonator **5020**, and thus, assumed to have a negligible or inconsequential effect on the natural frequency of the resonator **5020**. Accordingly, the oscillating component of the resonator **5020**, e.g., the pendulum **5030**, can be designed to amplify the haptic feedback generated by the electric motor **5002** (FIG. **170**) during the third operating state. Where the mass of the spring **5032** is substantially less than the mass of the weight **5034**, the natural frequency of the pendulum **5030** ($f_P$) can be approximated by the following relationship:

$$f_P \cong \frac{1}{2\pi}\sqrt{\frac{k_S}{m_W}},$$

wherein $k_S$ is the spring constant of the spring **5032** and $m_W$ is the mass of the weight **5034**. The spring constant of the spring **5032** ($k_S$) can be determined from the following relationship:

$$k_S = \frac{3E_S I_S}{L_S^3},$$

where $E_S$ is the modulus of elasticity of the spring **5032**, $I_S$ is the second moment of inertia of the spring **5032**, and $L_S$ is the length of the spring **5032**. In various embodiments, the spring constant ($k_S$) of the spring **5032** and/or the mass of the weight **5034** ($m_W$) can be selected such that the natural frequency of the pendulum **5030** ($f_P$) relates to the oscillation frequency of the electric motor **5002** during the third operating state. For example, the natural frequency of the pendulum **5030** can be optimized by varying the spring constant of the spring **5032** and/or the mass of the weight **5034**.

Referring still to FIGS. **170-172**, the natural frequency of the resonator **5020** and/or the pendulum **5030** thereof can be optimized to a frequency that provides the optimal haptic feedback to the operator. For example, the natural frequency of the resonator **5020** can be optimized to between approximately 50 Hz and approximately 300 Hz in order to enhance the feedback experienced by the operator. In some embodiments, the natural frequency of the resonator **5020** can be optimized to a frequency less than approximately 50 Hz, for example, and, in other embodiments, the resonator **5020** can be optimized for a frequency greater than approximately 300 Hz, for example. Furthermore, the electric motor **5002** (FIG. **170**) can oscillate at a frequency that drives the resonator **5020** to oscillate at or near the natural frequency thereof. In certain embodiments, the electric motor **5002** can drive the resonator **5020** to oscillate within a range of amplifying frequencies inclusive of the natural frequency of the resonator **5020**.

In various embodiments, the oscillation frequency of the electric motor **5002** can coincide with and/or correspond to the natural frequency of the resonator **5020** in order to drive the resonator **5020** at or near its natural frequency. In certain embodiments, the oscillation frequency of the electric motor **5002** can be near or at the natural frequency of the resonator **5020** and, in other embodiments, the oscillation frequency of the electric motor **5002** can be offset from the natural frequency of the resonator **5020**. In various embodiments, the oscillation frequency of the electric motor **5002** can be optimized to coincide with the natural frequency of the resonator **5020**. Furthermore, in certain embodiments, the oscillation frequency of the electric motor **5002** and the natural frequency of the resonator **5020** can be cooperatively selected, designed and/or optimized to amplify the haptic feedback generated by the electric motor **5002** during the third operating state.

Referring primarily to FIG. **170**, the electric motor **5002** can generate the amplified haptic feedback when the electric motor **5002** oscillates between the clockwise direction and the counterclockwise direction during the third operating state. Additionally, the rotation of the electric motor **5002** during the first and second operating states can drive the firing member (illustrated elsewhere) during a firing stroke. For example, clockwise rotation of the electric motor **5002** can advance the firing element distally and counterclockwise rotation of the electric motor **5002** can retract the firing element proximally. Accordingly, when the electric motor **5002** oscillates between the clockwise direction and the counterclockwise direction, the distal end of the firing element may move between a slightly more distal position and a slightly more proximal position. However, the electric motor **5002** can be significantly geared down such that oscillations of the electric motor **5002** during the third operating state move the distal end of the firing element an insignificant and/or imperceptible distance. In various embodiments, the gear ratio can be approximately 200:1 to approximately 800:1, for example. In certain embodiments, the firing element can remain stationary during the third operating state. For example, slack between the motor **5002** and distal end of the firing element can absorb the oscillations of the electric motor **5002**. For instance, referring to FIGS. **102-104**, such slack is present between the firing member **10060** and the knife bar **10066**. In various circumstances, the knife bar **10066** can comprise a drive tab **10065** which extends into a drive slot **10064** defined in the firing member **10060** wherein the length of the drive slot **10064** between a distal end **10067** and a proximal end **10069** thereof can be longer than the drive tab **10065**. In use, sufficient travel of the firing member **10060** must occur before the distal end **10067** or the proximal end **10069** come into contact with the drive tab **10065**.

Referring now to FIGS. **173-176**, the electric motor **5002** (FIGS. **173** and **174**) can be positioned within a handle **5101** (FIG. **173**) of a surgical instrument **5100** (FIG. **173**). In various embodiments, a resonator or amplifier **5120** can be mounted on the shaft **5006** of the electric motor **5002**. The shaft **5006** can be fixed to the rotor (not illustrated) positioned within the motor housing **5004**, and the shaft **5006** can rotate as the rotor rotates. The washer **5008** can secure the resonator **5120** relative to the shaft **5006**, for example. Furthermore, the resonator **5120** can be secured to the shaft **5006** such that the resonator **5120** rotates and/or moves with the shaft **5006**. In some circumstances, a key can be utilized to transmit the rotational movement of the shaft **5006** to the resonator **5120**, for example. In various circumstances, the resonator **5120** and/or various portions thereof can be fastened to the shaft **5006** and/or can be integrally formed therewith, for example.

Referring primarily to FIGS. **175** and **176**, similar to the resonator **5020**, the resonator **5120** can comprise a body **5122** comprising a mounting bore **5140** for receiving the shaft **5006** (FIGS. **173** and **174**) of the electric motor **5002** (FIGS. **173** and **174**). For example, the shaft **5006** can extend through the mounting bore **5140** when the resonator **5120** is secured to the shaft **5006**. In various embodiments, the body **5122** of the resonator **5120** can be balanced and symmetrical relative to the mounting bore **5140**, and the center of mass of the body **5122** can be positioned along the central axis of the mounting bore **5140**, for example. Further, the center of mass of the body **5122** can be positioned along the axis of rotation of the resonator **5120** and the shaft **5006** such that the body **5122** is balanced relative to the shaft **5006**, for example.

In various embodiments, the resonator **5120** can further comprise a pendulum **5130** extending from the body **5122**. For example, the pendulum **5130** can comprise a spring or bar **5132** extending from the body **5122** and a weight **5134** extending from the spring **5132**. In certain embodiments, the spring **5132** can extend along an axis that defines at least one contour between the body **5122** and the weight **5134**. The spring **5132** can wind, bend, twist, turn, crisscross, and/or zigzag, for example. The geometry of the spring **5132** can affect the spring constant thereof, for example. In at least one embodiment, the spring **5132** can form a first loop **5137** on a first lateral side of the resonator **5120** and a second loop **5138** on a second lateral side of the resonator **5120**. An intermediate portion **5139** of the spring **5132** can traverse between the first and second loops **5137**, **5138**, for example. Similar to the spring **5032**, the spring **5132** can be deflectable, and can deflect in response to rotations and/or oscillations of the resonator **5120**. Furthermore, in certain embodiments, the weight **5134** can include a pin **5136**, which can provide additional mass to the weight **5134**, for example. As described herein, the mass of the weight **5134** and the geometry and properties of the spring **5132** can be selected to optimize the natural frequency of the pendulum **5130**, and thus, the natural frequency of the entire resonator **5120**, for example.

Referring still to FIGS. **175** and **176**, the resonator **5120** can further comprise a counterweight **5124** extending from the body **5122**. In certain embodiments, a pin **5126** can extend from the counterweight **5124**, and can provide additional mass to the counterweight **5124**, for example. The pendulum **5130** can extend from the body **5122** in a first direction X, and the counterweight **5124** can extend from the body **5122** in a second direction Y. The second direction Y can be different than and/or opposite to the first direction X, for example. In various embodiments, the counterweight **5124** can be designed to balance the mass of the pendulum **5130** relative to the mounting bore **5140** through the body **5120**. For example, the geometry and material of the counterweight **5124** can be selected such that the center of mass **5128** of the resonator **5120** is positioned along the central axis of the mounting bore **5140** of the body **5122**, and thus, along the axis of rotation A (FIG. **173**) of the resonator **5120**.

Similar to the resonator **5020**, the resonator **5120** can be designed to amplify the haptic feedback generated by the electric motor **5002** (FIGS. **173** and **174**) during the third operating state. In other words, the resonator **5120** can be designed such that the natural frequency of the resonator **5120** is optimized, and the electric motor **5002** can oscillate at a frequency that drives the resonator **5120** to oscillate at or near its optimized natural frequency. For example, the electric motor **5002** can drive the resonator **5120** to oscillate within a range of amplifying frequencies inclusive of the natural frequency of the resonator **5120**. In certain embodiments, the natural frequency of the resonator **5120** can be approximated by the natural frequency of the pendulum **5130**. In such embodiments, the pendulum **5130** can be designed to amplify the haptic feedback generated by the electric motor **5002** during the third operating state. For example, the pendulum **5130** can be designed to have an optimized natural frequency, and the electric motor **5002** can drive the resonator **5120** to oscillate at or near the optimized natural frequency of the pendulum **5130** in order to amplify the haptic feedback generated during the third operating state.

Referring now to FIGS. **177-180**, the electric motor **5002** (FIGS. **177** and **178**) can be positioned within the handle **5101** (FIG. **177**) of the surgical instrument **5100** (FIG. **177**). In various embodiments, a resonator or amplifier **5220** can be mounted on the shaft **5006** (FIG. **170**) of the electric motor **5002**. The shaft **5006** can be fixed to the rotor (not illustrated) positioned within the housing **5004**, and the shaft **5006** can rotate as the rotor rotates. The washer **5008** (FIG. **170**) can secure the resonator **5220** relative to the shaft **5006**, for example. Furthermore, the resonator **5220** can be secured to the shaft **5006** such that the resonator **5220** rotates and/or moves with the shaft **5006**. In various embodiments, the resonator **5220** and/or various portions thereof can be fastened to the shaft **5006** and/or can be integrally formed therewith, for example.

Referring primarily to FIGS. **179** and **180**, similar to the resonators **5020**, **5120**, the resonator **5220** can comprise a body **5222** comprising a mounting bore **5240** for receiving the shaft **5006** (FIGS. **176** and **177**) of the electric motor **5002** (FIGS. **176** and **177**). For example, the shaft **5006** can extend through the mounting bore **5240** when the resonator **5220** is secured to the shaft **5006**. In various embodiments, the body **5222** of the resonator **5220** can be balanced and symmetrical relative to the mounting bore **5240**, and the center of mass of the body **5222** can be positioned along the central axis of the mounting bore **5240**, for example. Further, the center of mass of the body **5222** can be positioned along the axis of rotation of the shaft **5006** such that the body **5222** is balanced relative to the shaft **5006**, for example.

In various embodiments, the resonator **5220** can further comprise a pendulum **5230** extending from the body **5222**. For example, the pendulum **5230** can comprise a spring or bar **5232** extending from the body **5222** and a weight **5234** extending from the spring **5232**. In various embodiments, the spring **5232** can curve, wind, bend, twist, turn, crisscross, and/or zigzag between the body **5222** and the weight **5234**. Furthermore, in certain embodiments, the weight **5234** can include a pin **5236**, which can provide additional mass to the weight **5234**, for example. As described herein, the mass of the weight **5234** and the geometry and properties of the spring **5232** can be selected to optimize the natural frequency of the pendulum **5230**, and thus, the natural frequency of the entire resonator **5220**, for example.

In various embodiments, a retainer can limit or constrain radial elongation of the spring **5232** and/or the pendulum **5230** during rotation and/or oscillation. For example, a retainer can comprise a barrier or retaining wall around at least a portion of the pendulum **5230**. During the first and second operating states, for example, the spring **5232** may deform and extend the weight **5234** toward the barrier, which can prevent further elongation of the spring **5232**. For example, referring primarily to FIGS. **179** and **180**, the resonator **5220** can comprise a retainer **5244**. The retainer **5244** can comprise a first leg **5246**, which can be secured to the body **5222** and/or to a counterweight **5224** of the resonator **5220**. The first leg **5246** can be fixed to the resonator **5220**, and can be formed as an integral piece therewith and/or fastened thereto, for example. The retainer **5244** can further comprise a second leg or barrier leg **5248**, which can extend past the weight **5234** of the pendulum **5230** when the spring **5232** is undeformed. The barrier leg **5248** can define the radial boundary **5050** beyond which the pendulum **5230** cannot extend. In other words, the barrier leg **5248** can block radial extension of the pendulum **5230**. For example, the barrier leg **5248** can be out of contact with the pendulum **5230** when the spring **5232** is undeformed because the pendulum **5230** can be positioned within the radial boundary **5050**. In other words, a gap **5249** (FIG. **180**) can be defined between the weight **5234** and the barrier leg **5248** when the spring **5234** is undeformed. Further, the barrier leg **5248** can remain out of contact with the pendulum **5230** when the resonator **5220** oscillates during the third operating state. For example, the centrifugal force on the oscillating pendulum **5230** during the third operating state may be insufficient to extend the weight **5234** of the pendulum **5230** beyond the predefined radial boundary **5050** of the motor **5002**. Though the gap **5249** may be reduced during the third operating state, the weight **5234** can remain out of contact with the barrier leg **5248**, for example. In such embodiments, the natural frequency of the pendulum **5230** can be substantially unaffected by the retainer **5244** during the third operating state.

In various embodiments, when the resonator **5220** rotates during the first and second operating states, the spring **5232** of the pendulum **5230** can be substantially deformed and/or elongated. For example, the rotation of the resonator **5220** can generate a centrifugal force on the spring **5232**, and the spring **5232** may elongate in response to the centrifugal force. In certain embodiments, the weight **5234** of the pendulum **5230** can move toward and into abutting contact with the barrier leg **5248** of the retainer **5244**. In such embodiments, the barrier **5248** can limit or constrain further radial elongation of the spring **5232** during the first and second operating states.

In various embodiments, the retainer **5244** can be substantially rigid such that the retainer **5244** resists deformation and/or elongation. In certain embodiments, the retainer **5244** can be integrally formed with the resonator **5220** and/or secured relative thereto. In some embodiments, the retainer **5244** can be secured to the motor **5002** (FIGS. **177** and **178**). For example, the retainer **5244** can be fixed relative to the rotor and/or the shaft **5006** (FIGS. **177** and **178**) of the motor **5002** and can rotate and/or move therewith. In such embodiments, the retainer **5244** can rotate with the resonator **5220**, for example. In various embodiments, the retainer **5244** can be fastened to the motor **5002** and/or can be integrally formed therewith, for example. In certain embodiments, the retainer **5244** can remain stationary relative to the rotating shaft **5008** and/or resonator **5220**, for example.

Referring still to FIGS. **179** and **180**, the resonator **5220** can further comprise the counterweight **5224** extending from the body **5222**. In certain embodiments, a pin **5226** can extend from the counterweight **5224**, and can provide additional mass to the counterweight **5224**, for example. The pendulum **5230** can extend from the body **5222** in a first direction, and the counterweight **5224** can extend from the body **5222** in a second direction. The second direction can be different than and/or opposite to the first direction of the pendulum **5230**, for example. In various embodiments, the counterweight **5224** can be designed to balance the mass of the pendulum **5230** and the retainer **5244** relative to the mounting bore **5240** through the body **5220** of the resonator **5220**. For example, the geometry and material of the counterweight **5224** can be selected such that the center of mass **5228** of the resonator **5220** is positioned along the central axis of the mounting bore **5240** of the body **5222**, and thus, along the axis of rotation A (FIG. **177**) of the shaft **5008** (FIGS. **177** and **178**) and the resonator **5220**.

Similar to the resonators **5020**, **5120**, the resonator **5220** can be designed to amplify the haptic feedback generated by the electric motor **5002** during the third operating state. In other words, the resonator **5220** can be designed such that the natural frequency of the resonator **5220** is optimized, and the electric motor **5002** can oscillate at a frequency that drives the resonator **5220** to oscillate at or near its optimized natural frequency. For example, the electric motor **5002** can drive the resonator **5220** to oscillate within a range of amplifying frequencies inclusive of the natural frequency of the resonator **5220**. In certain embodiments, the natural frequency of the resonator **5220** can be approximated by the natural frequency of the pendulum **5230**. In such embodiments, the pendulum **5230** can be designed to amplify the haptic feedback generated by the electric motor **5002** during the third operating state. For example, the pendulum **5230** can be designed to have an optimized natural frequency, and the electric motor **5002** can drive the resonator **5220** to oscillate at or near the optimized natural frequency of the pendulum **5230** to amplify the haptic feedback generated during the third operating state.

Referring now to FIG. **181**, the electric motor **5002** can be positioned within the handle **5101** of the surgical instrument **5100**. In various embodiments, a resonator or amplifier **5320**, similar to resonator **5220**, for example, can be mounted on the shaft **5006** (FIG. **170**) of the electric motor **5002**. The resonator **5320** can comprise a body **5322** comprising a mounting bore **5340**, for example, a pendulum **5330** comprising a spring **5332**, a weight **5334**, and a pin **5336**, for example, and a counterweight **5324** comprising a pin **5326**, for example. In various embodiments, the center of mass of the resonator **5320** can lie along the axis of rotation A, and the geometry and material of the resonator **5230** can be selected to optimize the natural frequency thereof.

In various embodiments, a retaining ring **5344**, similar to retainer **5244**, can limit or constrain radial elongation of the spring **5332** and/or the pendulum **5230** during rotation and/or oscillation. In various embodiments, the retaining ring **5344** can comprise a barrier or retaining wall around at least a portion of the pendulum **5330**. In certain embodiments, the retaining ring **5344** can comprise a ring encircling the resonator **5320**, for example. In various embodiments, the retaining ring **5344** can be attached to the electric motor **5002**, such as the motor housing **5004**, for example. In other embodiments, the retaining ring **5344** can be attached to the handle **5101** of the surgical instrument **5100**, for example. In still other embodiments, the retaining ring **5344** can be attached to the rotor and/or the shaft **5006** (FIG. **170**) of the electric motor **5002** such that the retaining ring **5344** rotates with the shaft **5006** and/or the resonator **5320**, for example. In various embodiments, the retaining ring **5344** can be substantially rigid such that it resists deformation and/or elongation.

The retaining ring **5344** can define the radial boundary beyond which the pendulum **5330** cannot extend. For example, the pendulum **5330** can be out of contact with the retaining ring **5344** when the spring **5332** is undeformed. In other words, a gap can be defined between the weight **5334** of the pendulum **5330** and the retaining ring **5344** when the spring **5334** is undeformed. Further, the pendulum **5330** can remain out of contact with the retaining ring **5344** when the resonator **5320** oscillates during the third operating state. For example, the centrifugal force on the oscillating pendulum **5330** during the third operating state may be insufficient to extend the weight **5334** of the pendulum **5330** beyond the predefined radial boundary. Though the gap defined between the weight **5334** and the retaining ring **5344** may be reduced during the third operating state, the weight **5334** can remain out of contact with the retaining ring **5344**, for example. In such embodiments, the natural frequency of the pendulum **5330** can be substantially unaffected by the retaining ring **5344** during the third operating state.

In various embodiments, when the resonator **5320** rotates during the first and second operating states, the spring **5332** of the pendulum **5330** can be substantially deformed and/or elongated. For example, the rotation of the resonator **5320** can generate a centrifugal force on the spring **5332**, and the spring **5332** may elongate in response to the centrifugal force. In certain embodiments, the weight **5334** of the pendulum **5330** can move toward and into abutting contact with the retaining ring **5344**. In such embodiments, the retaining ring **5344** can limit or constrain further radial elongation of the spring **5332** during the first and second operating states.

In various embodiments, the surgical instrument **5100** (FIG. **177**) can comprise a control system (not shown), which can control the electric motor **5002**. In various embodiments, the control system can comprise one or more computers, processors, microprocessors, circuits, circuit elements (e.g., transistors, resistors, capacitors, inductors, and so forth), integrated circuits, application specific integrated circuits (ASIC), programmable logic devices (PLD), digital signal processors (DSP), field programmable gate array (FPGA), logic gates, registers, semiconductor device, chips, microchips, and/or chip sets, for example. The control system can initiate, pause, resume, and/or terminate various operating states of the electric motor **5002**. For example, the electric motor **5002** can perform a first function, e.g., advancing the firing element distally, during the first operating state, and can subsequently switch to the second operating state to perform a second function, e.g., retracting the firing element proximally. The firing element can be advanced distally to transect a predefined length of tissue, and/or to eject and/or form a predefined number of staples (illustrated elsewhere), for example. In various embodiments, when the predefined length of tissue has been transected and/or the predefined number of staples have been ejected and/or formed, the control system can control the electric motor **5002** to switch to the second operating state. The firing element can be retracted proximally during the second operating state to prepare for a subsequent firing stroke, for example. In certain embodiments, the electric motor **5002** can switch to the third operating state before the firing element completes the predefined transection length, and/or ejection and/or formation of the predefined number of staples. For example, the electric motor **5002** can prematurely switch from the first operating state to the third operating state to communicate a signal indicative of a condition of the surgical instrument to the operator. In various embodiments, the electric motor **5002** can switch to the third operating state to communicate a potential overload warning signal to the operator. In other embodiments, the amplified haptic feedback can communicate a status update to the operator such as, for example, a signal that the firing element has reached a distal-most position and/or successfully completed a firing stroke.

In various embodiments, the surgical instrument **5100** may be designed to overcome a maximum threshold force in order to transect tissue. When the force applied to the firing element exceeds the maximum threshold force, the surgical instrument **5100** may not perform as intended. For example, when the firing element attempts to transect thicker and/or tougher tissue, the thicker and/or tougher tissue may exert a force on the firing element that exceeds the maximum threshold force. Accordingly, the firing element may be unable to transect the thicker and/or tougher tissue. In such embodiments, the electric motor **5002** can switch to the third operating state in order to warn the operator that overload and/or failure of the surgical instrument **5100** is possible. In various embodiments, the surgical instrument **5100** can comprise a sensor (not shown). The sensor can be positioned in the end effector (illustrated elsewhere), for example, and can be configured to detect the force applied to the firing element during the firing sequence. In certain embodiments, the sensor and the control system can be in signal communication. In such embodiments, when the force detected by the sensor exceeds the maximum threshold force, the control system can switch the electric motor **5002** to the third operating state. In the third operating state, as described herein, advancement of the firing element can be paused and the electric motor can generate amplified haptic feedback to communicate the potential overload warning to the operator.

In response to the amplified haptic feedback, the operator can decide whether to resume the first operating state or to initiate the second operating state. For example, the operator can decide to resume advancement of the firing element distally, i.e., operate the surgical instrument in a warned operating state, or to heed the potential overload warning and retract the firing element proximally, i.e., operate the surgical instrument in a modified operating state. If the operator decides to operate the surgical instrument in the warned operating state, the surgical instrument **5100** may be at risk of failure. In various embodiments, the surgical instrument **5100** can comprise an input key (not shown), such as a plurality of lever(s) and/or button(s), for example. In various embodiments, the input key can be in signal communication with the control system. The operator can control the surgical instrument by entering input via the input key. For example, the operator can select a first button of the input key to resume advancement of the firing element, i.e., enter the warned operating state, or can select a second button of the input key to retract the firing element, i.e., enter the modified operating state. In various embodiments, the operator can select an additional button and/or lever to select yet a different operating state.

Though the surgical instrument **5100** may fail when operated in the warned operating state, the operator of the surgical instrument **5100** may decide that the failure risk is outweighed by the necessity and/or urgency of the surgical function. For example, when time is essential, the operator may decide that the risk of instrument failure is outweighed by a critical need to expeditiously complete (or attempt to complete) a surgical transection and/or stapling. Furthermore, by allowing the operator to determine the course of action, the holistic knowledge of the operator can be applied to the surgical procedure, and the operator is less likely to become confused and/or frustrated with the surgical instrument **5100**.

In various embodiments, a different motor can generate feedback to communicate with the operator. For example, a first motor can drive the firing member during a firing sequence, and a second motor can generate feedback. In various embodiments, the second motor can generate sensory feedback such as, for example, a noise, a light, and/or a tactile signal to communicate with the operator. Furthermore, in certain embodiments, the control system can control the multiple motors of the surgical instrument.

Referring primarily to FIG. **180**, a method of operating a surgical system or surgical instrument can include a plurality of operating states of the surgical instrument. For example, the surgical instrument can first operate in an initial operating state **5402**, and can subsequently operate in one of the secondary operating states **5412** or **5414**. The secondary operating state can be a warned operating state **5412**, for example, or a modified operating state **5414**, for example. When the surgical instrument operates in the initial operating state **5402**, an initial surgical function can be initiated at step S**404**. The initial surgical function can be one or more of various functions of the surgical instrument, such as, clamping tissue between jaws of an end effector, articulating the end effector, advancing the firing member, retracting the firing member, opening the end effector jaws, and/or repeating and/or combining various function(s), for example. After initiation of the initial surgical function, the surgical instrument can detect a condition of the surgical instrument at step S**406**. For example, where the initial surgical function is advancing the firing member, a sensor can detect a clinically-important condition, such as a force on the advancing firing member that exceeds a threshold force, for example.

Referring still to FIG. **180**, in response to the detected condition, the surgical instrument can pause the initial surgical function at step S**408**. Further, at step S**410** the surgical instrument can provide feedback to the operator of the surgical instrument. The feedback can be a sensory feedback, such as a noise, a light, and/or a tactile signal, for example. In certain embodiments, a first motor can pause the initial surgical function and a second motor can generate the sensory feedback. Alternatively, as described herein, a multi-function electric motor, such as the electric motor **5002**, for example, can switch from the first operating state, or advancing state, to the third operating state, or feedback state, in which the electric motor oscillates to generate the amplified haptic feedback. When the multi-function electric motor oscillates to generate the amplified haptic feedback, advancement and/or retraction of the firing element can be paused and/or reduced to an insignificant and/or imperceptible amount due to the high gear ratio between the electric motor and the firing member. In such embodiments, where the multi-function motor switches from the first operating state to the third operating state, pausing of the initial surgical function at step S**408** and providing feedback to the operator at step S**410** can occur simultaneously or nearly simultaneously, for example.



In certain embodiments, after the surgical instrument has communicated feedback indicative of a particular condition to the operator, the operator can determine how to proceed. For example, the operator can decide between a plurality of possible operating states. In various embodiments, the operator can decide to enter a warned operating state **5412**, or a modified operating state **5414**. For example, referring still to FIG. **180**, the operator can select the initial surgical function at step S**416**, or can select a modified surgical function at step S**418**. In various embodiments, the operator can interface with a key, button, and/or lever, for example, to select one of the secondary operating states. If the operator selects the initial surgical function at step S**416**, the surgical instrument can resume the initial surgical function at step S**418**. If the operator selects the modified surgical function at step S**420**, the surgical instrument can initiate the modified surgical function at step S**422**.

FIGS. **183-192** illustrate various embodiments of an apparatus, system, and method for absolute position sensing on rotary or linear drive endocutter. Microcontroller controlled endocutters require position and velocity values to be able to properly control articulation, firing, and other surgical functions. This has been accomplished in the past via use of rotary encoders attached to the drive motors, which enable the microcontroller to infer the position by counting the number of steps backwards and forwards the motor has taken. It is preferable, in various circumstances, to replace this system with a compact arrangement which provides a unique position signal to the microcontroller for each possible location of the drive bar or knife. Various exemplary implementations of such absolute position sensor arrangements for rotary or linear drive endocutter are now described with particularity in connection with FIGS. **183-192**.

FIG. **183** is an exploded perspective view of a surgical instrument handle **1042** of FIG. **34** showing a portion of a sensor arrangement **7002** for an absolute positioning system **7000**, according to one embodiment. The surgical instrument handle **1042** of FIG. **34** has been described in detail in connection with FIG. **34**. Accordingly, for conciseness and clarity of disclosure, other than describing the elements associated with the sensor arrangement **7002** for an absolute positioning system **7000**, such detailed description of the surgical instrument handle **1042** of FIG. **34** will not be repeated here. Accordingly, as shown in FIG. **183**, the surgical instrument handle **1042** of the housing **1040** operably supports a firing drive system **1100** that is configured to apply firing motions to corresponding portions of the interchangeable shaft assembly. The firing drive system **1100** may employ an electric motor **1102**. In various forms, the motor **1102** may be a DC brushed driving motor having a maximum rotation of, approximately, 25,000 RPM, for example. In other arrangements, the motor may include a brushless motor, a cordless motor, a synchronous motor, a stepper motor, or any other suitable electric motor. A battery **1104** (or "power source" or "power pack"), such as a Li ion battery, for example, may be coupled to the handle **1042** to supply power to a control circuit board assembly **1106** and ultimately to the motor **1102**. The battery pack housing **1104** may be configured to be releasably mounted to the handle **1042** for supplying control power to the surgical instrument **1010** (FIG. **33**). A number of battery cells connected in series may be used as the power source to power the motor. In addition, the power source may be replaceable and/or rechargeable.

As outlined above with respect to other various forms, the electric motor **1102** can include a rotatable shaft (not shown) that operably interfaces with a gear reducer assembly **1108** that is mounted in meshing engagement with a with a set, or rack, of drive teeth **1112** on a longitudinally-movable drive member **1110**. In use, a voltage polarity provided by the battery can operate the electric motor **1102** in a clockwise direction wherein the voltage polarity applied to the electric motor by the battery can be reversed in order to operate the electric motor **1102** in a counter-clockwise direction. When the electric motor **1102** is rotated in one direction, the drive member **1110** will be axially driven in the distal direction “D”. When the motor **1102** is driven in the opposite rotary direction, the drive member **1110** will be axially driven in a proximal direction “P”. The handle **1042** can include a switch which can be configured to reverse the polarity applied to the electric motor **1102** by the battery. As with the other forms described herein, the handle **1042** can also include a sensor that is configured to detect the position of the drive member **1110** and/or the direction in which the drive member **1110** is being moved.

FIG. **184** is a side elevational view of the handle of FIG. **183** with a portion of the handle housing removed showing a portion of a sensor arrangement **7002** for an absolute positioning system **7000**, according to one embodiment. The housing **1040** of the handle **1042** supports the control circuit board assembly **1106**, which comprises the necessary logic and other circuit components necessary to implement the absolute positioning system **7000**.

FIG. **185** is a schematic diagram of an absolute positioning system **7000** comprising a microcontroller **7004** controlled motor drive circuit arrangement comprising a sensor arrangement **7002**, according to one embodiment. The electrical and electronic circuit elements associated with the absolute positioning system **7000** and/or the sensor arrangement **7002** are supported by the control circuit board assembly **1106**. The microcontroller **7004** generally comprises a memory **7006** and a microprocessor **7008** (“processor”) operationally coupled. The processor **7008** controls a motor driver **7010** circuit to control the position and velocity of the motor **1102**. The motor **1102** is operatively coupled to a sensor arrangement **7002** and an absolute position sensor **7012** arrangement to provide a unique position signal to the microcontroller **7004** for each possible location of a drive bar or knife of the surgical instrument **1010** (FIG. **33**). The unique position signal is provided to the microcontroller **7004** over feedback element **7024**. It will be appreciated that the unique position signal may be an analog signal or digital value based on the interface between the position sensor **7012** and the microcontroller **7004**. In one embodiment described hereinbelow, the interface between the position sensor **7012** and the microcontroller **7004** is standard serial peripheral interface (SPI) and the unique position signal is a digital value representing the position of a sensor element **7026** over one revolution. The value representative of the absolute position of the sensor element **7026** over one revolution can be stored in the memory **7006**. The absolute position feedback value of the sensor element **7026** corresponds to the position of the articulation and knife elements. Therefore, the absolute position feedback value of the sensor element **7026** provides position feedback control of the articulation and knife elements.

The battery **1104**, or other energy source, provides power for the absolute positioning system **7000**. In addition, other sensor(s) **7018** may be provided to measure other parameters associated with the absolute positioning system **7000**. One or more display indicators **7020**, which may include an audible component, also may provided.

As shown in FIG. **185**, a sensor arrangement **7002** provides a unique position signal corresponding to the location of the longitudinally-movable drive member **1110**. The electric motor **1102** can include a rotatable shaft **7016** that operably interfaces with a gear assembly **7014** that is mounted in meshing engagement with a with a set, or rack, of drive teeth **1112** (FIG. **183**) on the longitudinally-movable drive member **1110**. The sensor element **7026** may be operably coupled to the gear assembly **7104** such that a single revolution of the sensor element **7026** corresponds to some linear longitudinal translation of the longitudinally-movable drive member **1110**, as described in more detail hereinbelow. In one embodiment, an arrangement of gearing and sensors can be connected to the linear actuator via a rack and pinion arrangement, or a rotary actuator via a spur gear or other connection. For embodiments comprising a rotary screw-drive configuration where a larger number of turns would be required, a high reduction gearing arrangement between the drive member and the sensor, like a worm and wheel, may be employed.

In accordance one embodiment of the present disclosure, the sensor arrangement **7002** for the absolute positioning system **7000** provides a more robust position sensor **7012** for use with surgical devices. By providing a unique position signal or value for each possible actuator position, such arrangement eliminates the need for a zeroing or calibration step and reduces the possibility of negative design impact in the cases where noise or power brown-out conditions may create position sense errors as in conventional rotary encoder configurations.

In one embodiment, the sensor arrangement **7002** for the absolute positioning system **7000** replaces conventional rotary encoders typically attached to the motor rotor and replaces it with a position sensor **7012** which generates a unique position signal for each rotational position in a single revolution of a sensor element associated with the position sensor **7012**. Thus, a single revolution of a sensor element associated with the position sensor **7012** is equivalent to a longitudinal linear displacement d1 of the of the longitudinally-movable drive member **1110**. In other words, d1 is the longitudinal linear distance that the longitudinally-movable drive member **1110** moves from point a to point b after a single revolution of a sensor element coupled to the longitudinally-movable drive member **1110**. The sensor arrangement **7002** may be connected via a gear reduction that results in the position sensor **7012** completing only a single turn for the full stroke of the longitudinally-movable drive member **1110**. With a suitable gear ratio, the full stroke of the longitudinally-movable drive member **1110** can be represented in one revolution of the position sensor **7012**.

A series of switches **7022***a* to **7022***n*, where n is an integer greater than one, may be employed alone or in combination with gear reduction to provide a unique position signal for more than one revolution of the position sensor **7012**. The state of the switches **7022***a*-**7022***n* are fed back to the microcontroller **7004** which applies logic to determine a unique position signal corresponding to the longitudinal linear displacement d1+d2+ . . . dn of the longitudinally-movable drive member **1110**.

Accordingly, the absolute positioning system **7000** provides an absolute position of the longitudinally-movable drive member **1110** upon power up of the instrument without retracting or advancing the longitudinally-movable drive member **1110** to a reset (zero or home) position as may be required with conventional rotary encoders that merely count the number of steps forwards or backwards that motor has taken to infer the position of a device actuator, drive bar, knife, and the like.

In various embodiments, the position sensor **7012** of the sensor arrangement **7002** may comprise one or more magnetic sensor, analog rotary sensor like a potentiometer, array of analog Hall-effect elements, which output a unique combination of position signals or values, among others, for example.

In various embodiments, the microcontroller **7004** may be programmed to perform various functions such as precise control over the speed and position of the knife and articulation systems. Using the known physical properties, the microcontroller **7004** can be designed to simulate the response of the actual system in the software of the controller **7004**. The simulated response is compared to (noisy and discrete) measured response of the actual system to obtain an "observed" response, which is used for actual feedback decisions. The observed response is a favorable, tuned, value that balances the smooth, continuous nature of the simulated response with the measured response, which can detect outside influences on the system.

In various embodiments, the absolute positioning system **7000** may further comprise and/or be programmed to implement the following functionalities. A feedback controller, which can be one of any feedback controllers, including, but not limited to: PID, state feedback and adaptive. A power source converts the signal from the feedback controller into a physical input to the system, in this case voltage. Other examples include, but are not limited to pulse width modulated (PWMed) voltage, current and force. The motor **1102** may be a brushed DC motor with a gearbox and mechanical links to an articulation or knife system. Other sensor(s) **7018** may be provided to measure physical parameters of the physical system in addition to position measured by the position sensor **7012**. Since it is a digital signal (or connected to a digital data acquisition system) its output will have finite resolution and sampling frequency. A compare and combine circuit may be provided to combine the simulated response with the measured response using algorithms such as, without limitation, weighted average and theoretical control loop that drives the simulated response towards the measured response. Simulation of the physical system takes in account of properties like mass, inertial, viscous friction, inductance resistance, etc. to predict what the states and outputs of the physical system will be by knowing the input.

In one embodiment, the microcontroller **7004** may be an LM 4F230H5QR, available from Texas Instruments, for example. In one embodiment, the Texas Instruments LM4F230H5QR is an ARM Cortex-M4F Processor Core comprising on-chip memory **7006** of 256 KB single-cycle flash memory, or other non-volatile memory, up to 40 MHz, a prefetch buffer to improve performance above 40 MHz, a 32 KB single-cycle serial random access memory (SRAM), internal read-only memory (ROM) loaded with StellarisWare software, 2 KB electrically erasable programmable read-only memory (EEPROM), two pulse width modulation (PWM) modules, with a total of 16 advanced PWM outputs for motion and energy applications, two quadrature encoder inputs (QEI) analog, two 12-bit Analog-to-Digital Converters (ADC) with 12 analog input channels, among other features that are readily available for the product datasheet. Other microcontrollers may be readily substituted for use in the absolute positioning system **7000**. Accordingly, the present disclosure should not be limited in this context.

In one embodiment, the driver **7010** may be a A3941 available from Allegro Microsystems, Inc. The A3941 driver **7010** is a full-bridge controller for use with external N-channel power metal oxide semiconductor field effect transistors (MOSFETs) specifically designed for inductive loads, such as brush DC motors. The driver **7010** comprises a unique charge pump regulator provides full (>10 V) gate drive for battery voltages down to 7 V and allows the A3941 to operate with a reduced gate drive, down to 5.5 V. A bootstrap capacitor may be employed to provide the above-battery supply voltage required for N-channel MOSFETs. An internal charge pump for the high-side drive allows DC (100% duty cycle) operation. The full bridge can be driven in fast or slow decay modes using diode or synchronous rectification. In the slow decay mode, current recirculation can be through the high-side or the lowside FETs. The power FETs are protected from shoot-through by resistor adjustable dead time. Integrated diagnostics provide indication of undervoltage, overtemperature, and power bridge faults, and can be configured to protect the power MOSFETs under most short circuit conditions. Other motor drivers may be readily substituted for use in the absolute positioning system **7000**. Accordingly, the present disclosure should not be limited in this context.

Having described a general architecture for implementing various embodiments of an absolute positioning system **7000** for a sensor arrangement **7002**, the disclosure now turns to FIGS. **186-192** for a description of one embodiment of a sensor arrangement for the absolute positioning system **7000**. In the embodiment illustrated in FIG. **186**, the sensor arrangement **7002** comprises a magnetic position sensor **7100**, a bipolar magnet **7102** sensor element, a magnet holder **7104** that turns once every full stroke of the longitudinally-movable drive member **1110** (FIGS. **183-185**), and a gear assembly **7106** to provide a gear reduction. A structural element such as bracket **7116** is provided to support the gear assembly **7106**, the magnet holder **7104**, and the magnet **7102**. The magnetic position sensor **7100** comprises one or more than one magnetic sensing elements such as Hall elements and is placed in proximity to the magnet **7102**. Accordingly, as the magnet **7102** rotates, the magnetic sensing elements of the magnetic position sensor **7100** determine the absolute angular position of the magnetic **7102** over one revolution.

In various embodiments, any number of magnetic sensing elements may be employed on the absolute positioning system **7000**, such as, for example, magnetic sensors classified according to whether they measure the total magnetic field or the vector components of the magnetic field. The techniques used to produce both types of magnetic sensors encompass many aspects of physics and electronics. The technologies used for magnetic field sensing include search coil, fluxgate, optically pumped, nuclear precession, SQUID, Hall-effect, anisotropic magnetoresistance, giant magnetoresistance, magnetic tunnel junctions, giant magnetoimpedance, magnetostrictive/piezoelectric composites, magnetodiode, magnetotransistor, fiber optic, magnetooptic, and microelectromechanical systems-based magnetic sensors, among others.

In the illustrated embodiment, the gear assembly **7106** comprises a first gear **7108** and a second gear **7110** in meshing engagement to provide a 3:1 gear ratio connection. A third gear **7112** rotates about shaft **7114**. The third gear is in meshing engagement with the longitudinally-movable drive member **1110** and rotates in a first direction as the longitudinally-movable drive member **1110** advances in a distal direction D (FIG. **183**) and rotates in a second direction as the longitudinally-movable drive member **1110** retracts in a proximal direction P (FIG. **183**). The second gear **7110** rotates about the same shaft **7114** and therefore, rotation of the second gear **7110** about the shaft **7114** corresponds to the longitudinal translation of the longitudinally-movable drive member **1110**. Thus, one full stroke of the longitudinally-movable drive member **1110** in either the distal or proximal directions D, P corresponds to three rotations of the second gear **7110** and a single rotation of the first gear **7108**. Since the magnet holder **7104** is coupled to the first gear **7108**, the magnet holder **7104** makes one full rotation with each full stroke of the longitudinally-movable drive member **1110**.

FIG. **187** is an exploded perspective view of the sensor arrangement **7002** for the absolute positioning system **7000** showing a control circuit board assembly **1106** and the relative alignment of the elements of the sensor arrangement **7002**, according to one embodiment. The position sensor **7100** (not shown in this view) is supported by a position sensor holder **7118** defining an aperture **7120** suitable to contain the position sensor **7100** is precise alignment with a rotating magnet **7102** below. The fixture **7120** is coupled to the bracket **7116** and to the control circuit board assembly **1106** and remains stationary while the magnet **7102** rotates with the magnet holder **7104**. A hub **7122** is provided to mate with the first gear **7108**/magnet holder **7104** assembly.

FIGS. **188-190** provide additional views of the sensor arrangement **7002**, according to one embodiment. In particular, FIG. **188** shows the entire sensor arrangement **7002** positioned in operational mode. The position sensor holder **7118** is located below the control circuit board assembly **1106** and encapsulates the magnet holder **7104** and magnet **7102**. FIG. **189** shows the magnet **7102** located below the aperture **7120** defined in the position sensor holder **7118**. The position sensor **7100** and the control circuit board assembly **1106** are not shown for clarity. FIG. **190** shows the sensor arrangement **7002** with the control circuit board assembly **1106**, the position sensor holder **7118**, the position sensor **7100**, and the magnet **7102** removed to show the aperture **7124** that receives the magnet **7102**.

FIG. **191** is a top view of the sensor arrangement **7002** shown with the control circuit board **1106** removed but the electronic components still visible to show the relative position between the position sensor **7100** and the circuit components **7126**, according to one embodiment. In the embodiment illustrated in connection with FIGS. **186-191**, the gear assembly **7106** composed of first gear **7108** and second gear **7110** have a 3:1 gear ratio such that three rotations of the second gear **7110** provides a single rotation of the first gear **7108** and thus the magnet holder **7104**. As previously discussed, the position sensor **7100** remains stationary while the magnet holder **7104**/magnet **7102** assembly rotates.

As discussed above, a gear assembly can be utilized to drive the magnet holder **7104** and the magnet **7102**. A gear assembly can be useful in various circumstances as the relative rotation between one gear in the gear assembly and another gear in the gear assembly can be reliably predicted. In various other circumstances, any suitable drive means can be utilized to drive the holder **7104** and the magnet **7102** so long as the relationship between the output of the motor and the rotation of the magnet **7102** can be reliably predicted. Such means can include, for example, a wheel assembly including at least two contacting wheels, such as plastic wheels and/or elastomeric wheels, for example, which can transmit motion therebetween. Such means can also include, for example, a wheel and belt assembly.

FIG. **192** is a schematic diagram of one embodiment of a position sensor **7100** sensor for an absolute positioning system **7000** comprising a magnetic rotary absolute positioning system, according to one embodiment. In one embodiment, the position sensor **7100** may be implemented as an AS5055EQFT single-chip magnetic rotary position sensor available from austriamicrosystems, AG. The position sensor **7100** is interfaced with the microcontroller **7004** to provide an absolute positioning system **7000**. The position sensor **7100** is a low voltage and low power component and includes four integrated Hall-effect elements **7128**A, **7128**B, **7128**C, **7128**D in an area **7130** of the position sensor **7100** that is located above the magnet **7104** (FIGS. **186**, **187**). A high resolution ADC **7132** and a smart power management controller **7138** are also provided on the chip. A CORDIC processor **7136** (for COordinate Rotation DIgital Computer), also known as the digit-by-digit method and Volder's algorithm, is provided to implement a simple and efficient algorithm to calculate hyperbolic and trigonometric functions that require only addition, subtraction, bitshift, and table lookup operations. The angle position, alarm bits and magnetic field information are transmitted over a standard SPI interface **7134** to the host processor, microcontroller **7004**. The position sensor **7100** provides 12 or 14 bits of resolution. In the embodiment illustrated in FIG. **191**, the position sensor **7100** is an AS5055 chip provided in a small QFN 16-pin 4×4×0.85 mm package.

The Hall-effect elements **7128**A, **7128**B, **7128**C, **7128**D are located directly above the rotating magnet. The Hall-effect is a well known effect and will not be described in detail herein for the sake of conciseness and clarity of disclosure. Generally, the Hall-effect is the production of a voltage difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current. It was discovered by Edwin Hall in **1879**. The Hall coefficient is defined as the ratio of the induced electric field to the product of the current density and the applied magnetic field. It is a characteristic of the material from which the conductor is made, since its value depends on the type, number, and properties of the charge carriers that constitute the current. In the AS5055 position sensor **7100**, the Hall-effect elements **7128**A, **7128**B, **7128**C, **7128**D are capable producing a voltage signal that is indicative of the absolute position of the magnet **7104** (FIGS. **186**, **187**) in terms of the angle over a single revolution of the magnet **7104**. This value of the angle, which is unique position signal, is calculated by the CORDIC processor **7136** is stored onboard the AS5055 position sensor **7100** in a register or memory. The value of the angle that is indicative of the position of the magnet **7104** over one revolution is provided to the host processor **7004** in a variety of techniques, e.g., upon power up or upon request by the host processor **7004**.

The AS5055 position sensor **7100** requires only a few external components to operate when connected to the host microcontroller **7004**. Six wires are needed for a simple application using a single power supply: two wires for power and four wires **7140** for the SPI serial communication interface **7134** with the host microcontroller **7004**. A seventh connection can be added in order to send an interrupt to the host microcontroller **7004** to inform that a new valid angle can be read.

Upon power-up, the AS5055 position sensor **7100** performs a full power-up sequence including one angle measurement. The completion of this cycle is indicated as an INT request at output pin **7142** and the angle value is stored in an internal register. Once this output is set, the AS5055 position sensor **7100** suspends to sleep mode. The external microcontroller **7004** can respond to the INT request at **7142** by reading the angle value from the AS5055 position sensor **7100** over the SPI interface **7134**. Once the angle value is read by the microcontroller **7004**, the INT output **7142** is cleared again. Sending a "read angle" command by the SPI interface **7134** by the microcontroller **7004** to the position sensor **7100** also automatically powers up the chip and starts another angle measurement. As soon ad the microcontroller **7004** has completed reading of the angle value, the INT output **7142** is cleared and a new result is stored in the angle register. The completion of the angle measurement is again indicated by setting the INT output **7142** and a corresponding flag in the status register.

Due to the measurement principle of the AS5055 position sensor **7100**, only a single angle measurement is performed in very short time (~600 μs) after each power-up sequence. As soon as the measurement of one angle is completed, the AS5055 position sensor **7100** suspends to power-down state. An on-chip filtering of the angle value by digital averaging is not implemented, as this would require more than one angle measurement and consequently, a longer power-up time which is not desired in low power applications. The angle jitter can be reduced by averaging of several angle samples in the external microcontroller **7004**. For example, an averaging of 4 samples reduces the jitter by 6 dB (50%).

As discussed above, the motor **1102** positioned within the handle **1042** of surgical instrument system **1000** can be utilized to advance and/or retract the firing system of the shaft assembly **1200**, including firing members **1272** and **1280**, for example, relative to the end effector **1300** of the shaft assembly **1200** in order to staple and/or incise tissue captured within the end effector **1300**. In various circumstances, it may be desirable to advance the firing members **1272** and **1280** at a desired speed, or within a range of desired speeds. Likewise, it may be desirable to retract the firing members **1272** and **1280** at a desired speed, or within a range of desired speeds. In various circumstances, the microcontroller **7004** of the handle **1042**, for example, and/or any other suitable controller, can be configured to control the speed of the firing members **1272** and **1280**. In some circumstances, the controller can be configured to predict the speed of the firing members **1272** and **1280** based on various parameters of the power supplied to the motor **1102**, such as voltage and/or current, for example, and/or other operating parameters of the motor **1102**. The controller can also be configured to predict the current speed of the firing members **1272** and **1280** based on the previous values of the current and/or voltage supplied to the motor **1102**, and/or previous states of the system like velocity, acceleration, and/or position. Furthermore, the controller can also be configured to sense the speed of the firing members **1272** and **1280** utilizing the absolute positioning sensor system described above, for example. In various circumstances, the controller can be configured to compare the predicted speed of the firing members **1272** and **1280** and the sensed speed of the firing members **1272** and **1280** to determine whether the power to the motor **1102** should be increased in order to increase the speed of the firing members **1272** and **1280** and/or decreased in order to decrease the speed of the firing members **1272** and **1280**. U.S. patent application Ser. No. 12/235,782, entitled MOTOR-DRIVEN SURGICAL CUTTING INSTRUMENT, now U.S. Pat. No. 8,210,411, is incorporated by reference in its entirety. U.S. patent application Ser. No. 11/343,803, entitled SURGICAL INSTRUMENT HAVING RECORDING CAPABILITIES, which issued on Dec. 7, 2010 as U.S. Pat. No. 7,845,537, is incorporated by reference in its entirety.

Using the physical properties of the instruments disclosed herein, turning now to FIGS. **198** and **199**, a controller, such as microcontroller **7004**, for example, can be designed to simulate the response of the actual system of the instrument in the software of the controller. The simulated response is compared to a (noisy and discrete) measured response of the actual system to obtain an "observed" response, which is used for actual feedback decisions. The observed response is a favorable, tuned, value that balances the smooth, continuous nature of the simulated response with the measured response, which can detect outside influences on the system. With regard to FIGS. **198** and **199**, a firing element, or cutting element, in the end effector **1300** of the shaft assembly **1200** can be moved at or near a target velocity, or speed. The systems disclosed in FIGS. **198** and **199** can be utilized to move the cutting element at a target velocity. The systems can include a feedback controller **4200**, which can be one of any feedback controllers, including, but not limited to a PID, a State Feedback, LQR, and/or an Adaptive controller, for example. The systems can further include a power source. The power source can convert the signal from the feedback controller **4200** into a physical input to the system, in this case voltage, for example. Other examples include, but are not limited to, pulse width modulated (PWM) voltage, frequency modulated voltage, current, torque, and/or force, for example.

With continued reference to FIGS. **198** and **199**, the physical system referred to therein is the actual drive system of the instrument configured to drive the firing member, or cutting member. One example is a brushed DC motor with gearbox and mechanical links to an articulation and/or knife system. Another example is the motor **1102** disclosed herein that operates the firing member **10060** and the articulation driver **10030**, for example, of an interchangeable shaft assembly. The outside influence **4201** referred to in FIGS. **198** and **199** is the unmeasured, unpredictable influence of things like tissue, surrounding bodies and friction on the physical system, for example. Such outside influence can be referred to as drag and can be represented by a motor **4202** which acts in opposition to the motor **1102**, for example. In various circumstances, outside influence, such as drag, is the primary cause for deviation of the simulation of the physical system from the actual physical system. The systems depicted in FIGS. **198** and **199** and further discussed below can address the differences between the predicted behavior of the firing member, or cutting member, and the actual behavior of the firing member, or cutting member.

With continued reference to FIGS. **198** and **199**, the discrete sensor referred to therein measures physical parameters of the actual physical system. One embodiment of such a discrete sensor can include the absolute positioning sensor **7102** and system described herein. As the output of such a discrete sensor can be a digital signal (or connected to a digital data acquisition system) its output may have finite resolution and sampling frequency. The output of the discrete sensor can be supplied to a microcontroller, such as microcontroller **7004**, for example. In various circumstances, the microcontroller can combine the simulated, or estimated, response with the measured response. In certain circumstances, it may be useful to use enough measured response to ensure that the outside influence is accounted for without making the observed response unusably noisy. Examples for algorithms that do so include a weighted average and/or a theoretical control loop that drives the simulated response towards the measured response, for example. Ultimately, further to the above, the simulation of the physical system takes in account of properties like mass, inertial, viscous friction, and/or inductance resistance, for example, to predict what the states and outputs of the physical system will be by knowing the input. FIG. **199** shows an addition of evaluating and measuring the current supplied to operate the actual system, which is yet another parameter that can be evaluated for controlling the speed of the cutting member, or firing member, of the shaft assembly **1200**, for example. By measuring current in addition to or in lieu of measuring the voltage, in certain circumstances, the physical system can be made more accurate. Nonetheless, the ideas disclosed herein can be extended to the measurement of other state parameters of other physical systems.

Having described various embodiments of an absolute positioning system **7000** to determine an absolute position signal/value of a sensor element corresponding to a unique absolute position of elements associated with articulation and firing, the disclosure now turns to a description of several techniques for employing the absolute position/value in a position feedback system to control the position of the articulation and knife to compensate for knife band splay in a powered articulated surgical instrument **1010** (FIG. **33**). The absolute positioning system **7000** provides a unique position signal/value to the microcontroller for each possible location of the drive bar or knife along the length of the staple cartridge.

The operation of the articulation joint **1350** has been described in connection with FIG. **37** and will not be repeated in detail in this section for conciseness and clarity of disclosure. The operation of the articulation joint **10090** has been described in connection with FIG. **102** and will not be repeated in detail in this section for conciseness and clarity of disclosure. FIG. **193** illustrates an articulation joint **8000** in a straight position, i.e., at a zero angle $\theta_0$ relative to the longitudinal direction depicted as longitudinal axis L-A, according to one embodiment. FIG. **195** illustrates the articulation joint **8000** of FIG. **193** articulated in one direction at a first angle $\theta_1$ defined between the longitudinal axis L-A and the articulation axis A-A, according to one embodiment. FIG. **195** illustrates the articulation joint **8000** of FIG. **194** articulated in another direction at a second angle $\theta_2$ defined between the longitudinal axis L-A and the articulation axis A'-A, according to one embodiment.

The surgical instrument according to the present disclosure utilizes multiple flexible knife bands **8002** to transfer compressive force to a translating a knife element in the cartridge (not shown) of the end effector **1300** (FIG. **37**). The flexible knife bands **8002** enable the end-effector **1300** (FIG. **33**) to articulate through a variety of angles θ. The act of articulating, however, causes the flexible knife bands **8002** to splay. Splay of the flexible knife bands **8002** changes the effective transection length $T_1$ in the longitudinal direction. Thus, it is difficult to determine the exact position of the knife past the articulation joint **8000** when the flexible knife bands **8002** are articulated past an angle of θ=0. As previously discussed, the position of the articulation and knife element can be determined directly using the absolute position feedback signal/value from the absolute positioning system **7000** when the articulation angle is zero $\theta_o$ as shown in FIG. **194**. However, when the flexible knife bands **8002** deviate from a zero angle $\theta_0$ from the longitudinal axis L-A, the absolute position of the knife within the cartridge cannot be precisely determined based on the absolute position signal/value provided by the absolute positioning system **7000** to the microcontroller **7004**, without knowing the articulation angle θ.

In one embodiment, the articulation angle θ can be determined fairly accurately based on the firing drive of the surgical instrument. As outlined above, the movement of the firing member **10060** can be tracked by the absolute positioning system **7000** wherein, when the articulation drive is operably coupled to the firing member **10060** by the clutch system **10070**, for example, the absolute positioning system **7000** can, in effect, track the movement of the articulation system via the firing member **10060**. As a result of tracking the movement of the articulation system, the controller of the surgical instrument can track the articulation angle θ of the end effector, such as end effector **10020**, for example. In various circumstances, as a result, the articulation angle θ can be determined as a function of longitudinal displacement $D_L$ of the flexible knife bands **8002**. Since the longitudinal displacement $D_L$ of the flexible knife bands **8002** can be precisely determined based on the absolute position signal/value provided by the absolute positioning system **7000**, an algorithm may be employed to compensate for the error in displacement of the knife following the articulation joint **8000**.

In another embodiment, the articulation angle θ can be determined by locating sensors on the flexible knife bands **8002** distal D to the articulation joint **8000**. The sensors can be configured to sense the amount of tension or compression in the articulated flexible knife bands **8002**. The measured tension or compression results are provided to the microcontroller **7004** to calculate the articulation angle θ based on the amount of tension or compression measured in the knife bands **8002**. Suitable sensors such as microelectronic mechanical systems (MEMS) devices and strain gauges may be readily adapted to make such measurements. Other techniques include locating a tilt sensor, inclinometer, accelerometer, or any suitable device for measuring angles, in the articulation joint **8000** to measure the articulation angle θ.

In various embodiments, several techniques for compensating for splay of the flexible knife bands **8002** in a powered articulatable surgical instrument **1010** (FIG. **33**) are described hereinbelow in the context of a powered surgical instrument **1010** comprising an absolute positioning system **7000** and a microcontroller **7004** with data storage capability such as memory **7006**.

FIG. **196** illustrates one embodiment of a logic diagram **8100** for a method of compensating for the effect of splay in flexible knife bands **8002** on transection length $T_1$. The method will be described in connection with FIGS. **185** and **192-196**. Accordingly, in one embodiment of a method **8100** of compensating for the effect of splay in flexible knife bands **8002** on transection length $T_1$, the relationship between articulation angle θ of the end effector **1300** (FIG. **37**), or end effector **10020** (FIG. **102**), for example, and effective transection length $T_1$ distal of the articulation joint **8000** is initially characterized and the characterization data is stored in the memory **7006** of the surgical instrument **1010** (FIG. **33**). In one embodiment, the memory **7006** is a nonvolatile memory such as flash memory, EEPROM, and the like. The processor **7008** portion of the microcontroller **7004** accesses **8102** the characterization data stored in the memory **7006**. The processor **7008** tracks **8104** the articulation angle of the end effector **1300** during use of the surgical instrument **1010**. The processor **7008** adjusts **8106** the target transection length $T_1$ by the surgical instrument **1010** based on the known articulation angle $\theta_M$ and the stored characterization data representative of the relationship between the articulation angle $\theta_S$ and the transection length $T_1$.

In various embodiments, the characterization data representative of the relationship between the articulation angle θ of the end effector **1300** (FIG. **37**) and the effective transection length $T_1$ may be completed for the shaft of the surgical instrument **1010** (FIG. **33**) during manufacturing. In one embodiment, the output of the characterization **8102** process is a lookup table implemented in the memory **7006**. Accordingly, in one embodiment, the processor **7008** accesses the characterization data from the lookup table implemented in the memory **7006**. In one aspect, the lookup table comprises an array that replaces runtime computation with a simpler array indexing operation. The savings in terms of processing time can be significant, since retrieving a value from the memory **7006** by the processor **7008** is generally faster than undergoing an "expensive" computation or input/output operation. The lookup table may be precalculated and stored in static program storage, calculated (or "pre-fetched") as part of a program's initialization phase (memorization), or even stored in hardware in application-specific platforms. In the instant application, the lookup table stores the output values of the characterization of the relationship between articulation angle of the end effector **1300** (FIG. **37**) and effective transection length. The lookup table stores these output values in an array and, in some programming languages, may include pointer functions (or offsets to labels) to process the matching input. Thus, for each unique value of linear displacement $D_L$ there is a corresponding articulation angle θ. The articulation angle **8** is used to calculate a corresponding transection length $T_1$ displacement distal the articulation joint **8000**, the articulation joint **1350**, or the articulation joint **10090**, for example. The corresponding transection length $T_1$ displacement is stored in the lookup table and is used by the microcontroller **7004** to determine the position of the knife past the articulation joint. Other lookup table techniques are contemplated within the scope of the present disclosure.

In one embodiment, the output of the characterization **8102** process is a best curve fit formula, linear or nonlinear. Accordingly, in one embodiment, the processor **7008** is operative to execute computer readable instructions to implement a best curve fit formula based on the characterization data. Curve fitting is the process of constructing a curve, or mathematical function that has the best fit to a series of data points, possibly subject to constraints. Curve fitting can involve either interpolation, where an exact fit to the data is required. In the instant disclosure, the curve represents the transection length $T_1$ displacement of the flexible knife bands **8002** distal D of the articulated articulation joint **8000** (FIG. **37**) based on the articulation angle θ, which depends on the linear displacement $D_L$ of the flexible knife bands **8002** proximal P to the articulation joint **1350**. The data points such as linear displacement $D_L$ of the flexible knife bands **8002** proximal to the articulation joint **1350**, displacement $T_1$ of the flexible knife bands **8002** distal the articulated articulation joint **1350**, and articulation angle θ can be measured and used to generate a best fit curve in the form of an $n^{th}$ order polynomial (usually a $3^{rd}$ order polynomial would provide a suitable curve fit to the measured data). The microcontroller **7004** can be programmed to implement the $n^{th}$ order polynomial. In use, input the $n^{th}$ order polynomial is the linear displacement of the flexible knife bands **8002** derived from the unique absolute position signal/value provided by the absolute positioning system **7000**.

In one embodiment, the characterization **8102** process accounts for articulation angle θ and compressive force on the knife bands **8002**.

In one embodiment, the effective transection length is a distance between the distal most surface of the knife blade in relationship to a predetermined reference in the handle of the surgical instruments **1010**.

In various embodiments, the memory **7006** for storing the characterization may be a nonvolatile memory located on the on the shaft, the handle, or both, of the surgical instrument **1010** (FIG. **33**).

In various embodiments, the articulation angle θ can be tracked by a sensor located on the shaft of the surgical instrument **1010** (FIG. **33**). In other embodiments, the articulation angle θ can be tracked by a sensor on the handle of the surgical instrument **1010** or articulation angle θ can be tracked by variables within the control software for the surgical instrument **1010**.

In one embodiment, the characterization is utilized by control software of the microcontroller **7004** communicating with the non-volatile memory **7006** to gain access to the characterization.

Various embodiments described herein are described in the context of staples removably stored within staple cartridges for use with surgical stapling instruments. In some circumstances, staples can include wires which are deformed when they contact an anvil of the surgical stapler. Such wires can be comprised of metal, such as stainless steel, for example, and/or any other suitable material. Such embodiments, and the teachings thereof, can be applied to embodiments which include fasteners removably stored with fastener cartridges for use with any suitable fastening instrument.

Various embodiments described herein are described in the context of linear end effectors and/or linear fastener cartridges. Such embodiments, and the teachings thereof, can be applied to non-linear end effectors and/or non-linear fastener cartridges, such as, for example, circular and/or contoured end effectors. For example, various end effectors, including non-linear end effectors, are disclosed in U.S. patent application Ser. No. 13/036,647, entitled SURGICAL STAPLING INSTRUMENT, which issued on Oct. 22, 2013 as U.S. Pat. No. 8,561,870, which is hereby incorporated by reference in its entirety. Additionally, U.S. patent application Ser. No. 12/893,461, entitled STAPLE CARTRIDGE, which issued on May 27, 2014 as U.S. Pat. No. 8,733,613, is hereby incorporated by reference in its entirety. U.S. patent application Ser. No. 12/031,873, entitled END EFFECTORS FOR A SURGICAL CUTTING AND STAPLING INSTRUMENT, which issued on Jul. 19, 2011 as U.S. Pat. No. 7,980,443, is also hereby incorporated by reference in its entirety. U.S. patent application Ser. No. 12/894,377, entitled SELECTIVELY ORIENTABLE IMPLANTABLE FASTENER CARTRIDGE, which issued on Mar. 12, 2013 as U.S. Pat. No. 8,393,514, is also hereby incorporated by reference in its entirety.

## Examples

A surgical instrument for treating tissue can comprise a handle including a trigger, a shaft extending from the handle, an end effector, and an articulation joint, wherein the end effector is rotatably coupled to the shaft by the articulation joint. The surgical instrument can further comprise a firing member operably coupled with the trigger, wherein the operation of the trigger is configured to advance the firing member toward the end effector, and an articulation member operably coupled with the end effector. The articulation member is selectively engageable with the firing member such that the articulation member is operably engaged with the firing member in an engaged configuration and such that the articulation member is operably disengaged from the firing member in a disengaged configuration, wherein the firing member is configured to advance the articulation member toward the end effector to rotate the end effector about the articulation joint when the articulation member and the firing member are in the engaged configuration. The surgical instrument can further include a biasing member, such as a spring, for example, which can be configured to re-center the end effector and re-align the end effector with the shaft along a longitudinal axis after the end effector has been articulated.

A surgical instrument for treating tissue can comprise an electric motor, a shaft, an end effector, and an articulation joint, wherein the end effector is rotatably coupled to the shaft by the articulation joint. The surgical instrument can further comprise a firing drive operably engageable with the electric motor, wherein the firing drive is configured to be advanced toward the end effector and retracted away from the end effector by the electric motor. The surgical instrument can also comprise an articulation drive operably coupled with the end effector, wherein the articulation drive is configured to rotate the end effector in a first direction when the articulation drive is pushed distally toward the end effector, wherein the articulation drive is configured to rotate the end effector in a second direction when the articulation drive is pulled proximally away from the end effector, wherein the firing drive is selectively engageable with the articulation drive and is configured to at least one of push the articulation drive distally toward the end effector and pull the articulation drive away from the end effector when the firing drive is operably engaged with the articulation drive, and wherein the firing drive can operate independently of the articulation drive when the firing drive is operably disengaged from the articulation drive.

A surgical instrument for treating tissue can comprise a shaft, an end effector rotatably coupled to the shaft, and a firing member configured to be moved relative to the end effector. The surgical instrument can further comprise an articulation member operably coupled with the end effector, wherein the articulation member is selectively engageable with the firing member such that the articulation member is operably engaged with the firing member in an engaged configuration and such that the articulation member is operably disengaged from the firing member in a disengaged configuration, and wherein the firing member is configured to move the articulation member relative to the end effector to rotate the end effector when the articulation member and the firing member are in the engaged configuration. The surgical instrument can further comprise an end effector lock configurable in a locked configuration and an unlocked configuration, wherein the end effector lock is configured to operably engage the articulation member with the firing member when the end effector lock is in the unlocked configuration.

A surgical instrument that may include at least one drive system that is configured to generate control motions and which defines an actuation axis. The surgical instrument may further comprise at least one interchangeable shaft assembly that is configured to be removably coupled to the at least one drive system in a direction that is substantially transverse to the actuation axis and transmit the control motions from the at least one drive system to a surgical end effector operably coupled to the interchangeable shaft assembly. In addition, the surgical instrument may further include a lockout assembly that interfaces with the at least one drive system for preventing actuation of the drive system unless the at least one interchangeable shaft assembly has been operably coupled to the at least one drive system.

A surgical instrument that comprises a shaft assembly that includes an end effector. The end effector may comprise a surgical staple cartridge and an anvil that is movably supported relative to the surgical staple cartridge. The shaft assembly may further comprise a movable closure shaft assembly that is configured to apply opening and closing motions to the anvil. A shaft attachment frame may operably support a portion of the movable closure shaft assembly thereon. The surgical instrument may further comprise a frame member that is configured for removable operable engagement with the shaft attachment frame and a closure drive system that is operably supported by the frame member and defines an actuation axis. The closure drive system may be configured for operable engagement with the closure shaft assembly in a direction that is substantially transverse to the actuation axis when the shaft attachment frame is in operable engagement with the frame member. A lockout assembly may interface with the closure drive system for preventing actuation of the closure drive system unless the closure shaft assembly is in operable engagement with the closure drive system.

A surgical system that may comprise a frame that operably supports at least one drive system for generating control motions upon actuation of a control actuator. At least one of the drive systems defines an actuation axis. The surgical system may further comprise a plurality of interchangeable shaft assemblies wherein each interchangeable shaft assembly may comprise a shaft attachment frame that is configured to removably operably engage a portion of the frame in a direction that is substantially transverse to the actuation axis. A first shaft assembly may be operably supported by the shaft attachment frame and be configured for operable engagement with a corresponding one of the at least one drive systems in the direction that is substantially transverse to the actuation axis. A lockout assembly may mechanically engage a portion of the corresponding one of the at least one drive systems and cooperate with the control actuator to prevent actuation of the control actuator until the shaft attachment frame is in operable engagement with the frame portion and the first shaft assembly is in operable engagement with the one of the at least one drive systems.

An interchangeable shaft assembly can be used with a surgical instrument. In at least one form, the surgical instrument includes a frame that operably supports a plurality of drive systems and defines an actuation axis. In one form, the shaft assembly comprises a first shaft that is configured to apply first actuation motions to a surgical end effector operably coupled thereto, wherein a proximal end of the first shaft is configured to be operably releasably coupled to a first one of the drive systems supported by the frame in a direction that is substantially transverse to the actuation axis.

An interchangeable shaft assembly can be used with a surgical instrument. In at least one form, the surgical instrument may include a frame that defines an actuation axis and operably supports a plurality of drive systems. Various forms of the shaft assembly may comprise a shaft frame that has a shaft attachment module attached to a proximal end thereof and is configured to be releasably coupled to a portion of the frame in a direction that is substantially transverse to the actuation axis. The shaft assembly may further comprise an end effector that is operably coupled to a distal end of the shaft frame. In at least one form, the end effector comprises a surgical staple cartridge and an anvil that is movably supported relative to the surgical staple cartridge. The shaft assembly may further comprise an outer shaft assembly that includes a distal end that is configured to apply control motions to the anvil. The outer shaft assembly may include a proximal end that is configured to be operably releasably coupled to a first one of the drive systems supported by the frame in a direction that is substantially transverse to the actuation axis. The shaft assembly may also comprise a firing shaft assembly that includes a distal cutting portion that is configured to move between a starting position and an ending position within the end effector. The firing shaft assembly may include a proximal end that is configured to be operably releasably coupled to a firing drive system supported by the frame in the direction that is substantially transverse to the actuation axis.

A surgical system may comprise a frame that supports a plurality of drive systems and defines an actuation axis. The system may further comprise a plurality of interchangeable shaft assemblies. Each interchangeable shaft assembly may comprise an elongate shaft that is configured to apply first actuation motions to a surgical end effector operably coupled thereto, wherein a proximal end of the elongate shaft is configured to be operably releasably coupled to a first one of the drive systems supported by the frame in a direction that is substantially transverse to the actuation axis. Each interchangeable shaft assembly may further comprise a control shaft assembly that is operably supported within the elongate shaft and is configured to apply control motions to the end effector and wherein a proximal end of the control shaft assembly is configured to be operably releasably coupled to a second one of the drive systems supported by the frame in the direction that is substantially transverse to the actuation axis and wherein at least one of the surgical end effectors differs from another one of the surgical end effectors.

Those of ordinary skill in the art will understand that the various surgical instrument arrangements disclosed herein include a variety of mechanisms and structures for positive alignment and positive locking and unlocking of the interchangeable shaft assemblies to corresponding portion(s) of a surgical instrument, whether it be a hand-held instrument or a robotically-controlled instrument. For example, it may be desirable for the instrument to be configured to prevent actuation of one or more (including all) of the drive systems at an incorrect time during instrument preparation or while being used in a surgical procedure.

A housing for use with a surgical instrument that includes a shaft and an end effector, wherein the surgical instrument includes an articulation assembly configured to move the end effector relative to the shaft. The housing comprises a motor operably supported by the housing, an articulation drive configured to transmit at least one articulation motion to the articulation assembly to move the end effector between an articulation home state position and an articulated position, a controller in communication with the motor, a first input configured to transmit a first input signal to the controller, wherein the controller is configured to activate the motor to generate the at least one articulation motion to move the end effector to the articulated position in response to the first input signal, and a reset input configured to transmit a reset input signal to the controller, wherein the controller is configured to activate the motor to generate at least one reset motion to move the end effector to the articulation home state position in response to the reset input signal.

A surgical instrument comprises a shaft, an end effector extending distally from the shaft, wherein the end effector is movable relative to the shaft between an articulation home state position and an articulated position. The end effector comprises a staple cartridge including a plurality of staples and a firing member configured to fire the plurality of staples, wherein the firing member is movable between a firing home state position and a fired position. In addition, the surgical instrument comprises a housing extending proximally from the shaft. The housing comprises a motor operably supported by the housing, a controller in communication with the motor, and a home state input configured to transmit a home state input signal to the controller, wherein the controller is configured to activate the motor in response to the home state input signal to effectuate a return of the end effector to the articulation home state position and a return of the firing member to the firing home state position.

A surgical instrument comprises an end effector, a shaft extending proximally from the end effector, an articulation assembly configured to move the end effector relative to the shaft between an unarticulated position, a first articulated position on a first side of the unarticulated position, and a second articulated position on a second side of the unarticulated position, wherein the first side is opposite the second side. In addition, the surgical instrument further comprises a motor, a controller in communication with the motor, a first input configured to transmit a first input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the first articulated position in response to the first input signal, a second input configured to transmit a second input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the second articulated position in response to the second input signal, and a reset input configured to transmit a reset input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the unarticulated position in response to the reset input signal.

A surgical instrument comprises an end effector, a shaft extending proximally from the end effector, a firing assembly configured to fire a plurality of staples, an articulation assembly configured to articulate the end effector relative to the shaft, a locking member movable between a locked configuration and an unlocked configuration, and a housing extending proximally from the shaft, wherein the housing is removably couplable to the shaft when the locking member is in the unlocked configuration. The housing comprises a motor configured to drive at least one of the firing assembly and the articulation assembly, and a controller in communication with the motor, wherein the controller is configured to activate the motor to reset at least one of the firing assembly and the articulation assembly to a home state when the locking member is moved between the locked configuration and the unlocked configuration.

A surgical instrument comprises an end effector, a shaft extending proximally from the end effector, a firing assembly configured to fire a plurality of staples, an articulation assembly configured to articulate the end effector relative to the shaft, a locking member movable between a locked configuration and an unlocked configuration, and a housing extending proximally from the shaft, wherein the housing is removably couplable to the shaft when the locking member is in the unlocked configuration. The housing comprises a motor configured to drive at least one of the firing assembly and the articulation assembly, a controller in communication with the motor, and a home state input operably coupled to the locking member, wherein the home state input is configured to transmit a home state input signal to the controller, and wherein the controller is configured to activate the motor to reset at least one of the firing assembly and the articulation assembly to a home state in response to the home state input signal.

A surgical instrument comprises an end effector, a shaft extending proximally from the end effector, an articulation assembly configured to articulate the end effector relative to the shaft between a home state position and an articulated position, a locking member movable between a locked configuration and an unlocked configuration, and a housing extending proximally from the shaft, wherein the housing is removably couplable to the shaft when the locking member is in the unlocked configuration. The housing comprises a motor configured to drive the articulation assembly, and a controller in communication with the motor, wherein the controller is configured to activate the motor to effectuate a return of the end effector to the home state position when the locking member is moved between the locked configuration and the unlocked configuration.

An absolute position sensor system for a surgical instrument can comprise, one, a sensor element operatively coupled to a movable drive member of the surgical instrument and, two, a position sensor operably coupled to the sensor element, the position sensor configured to sense the absolute position of the sensor element.

A surgical instrument can comprise, one, an absolute position sensor system comprising a sensor element operatively coupled to a movable drive member of the surgical instrument and a position sensor operably coupled to the sensor element, the position sensor configured to sense the absolute position of the sensor element and, two, a motor operatively coupled to the movable drive member.

An absolute position sensor system for a surgical instrument can comprise, one, a sensor element operatively coupled to a movable drive member of the surgical instrument, two, a holder to hold the sensor element, wherein the holder and the sensor element are rotationally coupled and, three, a position sensor operably coupled to the sensor element, the position sensor configured to sense the absolute position of the sensor element, wherein the position sensor is fixed relative to the rotation of the holder and the sensor element.

A method of compensating for the effect of splay in flexible knife bands on transection length of a surgical instrument comprising a processor and a memory, wherein the surgical instrument comprises stored in the memory characterization data representative of a relationship between articulation angle of an end effector and effective transection length distal of an articulation joint, comprising the steps of, one, accessing, by the processor, the characterization data from the memory of the surgical instrument, two, tracking, by the processor, the articulation angle of the end effector during use of the surgical instrument and, three, adjusting, by the processor, the target transection length by the surgical instrument based on the tracked articulation angle and the stored characterization data.

A surgical instrument can comprise a microcontroller comprising a processor configured to execute computer readable instructions and a memory coupled to the microcontroller, wherein the processor is operative to, one, access from the memory characterization data representative of a relationship between articulation angle of an end effector and effective transection length distal of an articulation joint, two, track the articulation angle of the end effector during use of the surgical instrument and, three, adjust the target transection length based on the tracked articulation angle and the stored characterization data.

A surgical instrument can comprise an end effector comprising an articulation joint, flexible knife bands configured to translate from a position proximal of the articulation joint to a position distal of the articulation joint, a microcontroller comprising a processor operative to execute computer readable instructions, and a memory coupled to the microcontroller. The processor is operative to, one, access from the memory characterization date representative of a relationship between articulation angle of an end effector and effective transection length distal of the articulation joint, two, track the articulation angle of the end effector during use of the surgical instrument and, three, adjust the target transection length based on the known articulation angle and the stored characterization data.

A shaft assembly for use with a surgical instrument can comprise a shaft, an end effector, an articulation joint connecting the end effector to the shaft, a firing driver movable relative to the end effector, an articulation driver configured to articulate the end effector about the articulation joint, and a clutch collar configured to selectively engage the articulation driver to the firing driver to impart the movement of the firing driver to the articulation driver.

A surgical instrument can comprise a handle, an electric motor positioned in the handle, a shaft attachable to the handle, an end effector, an articulation joint connecting the end effector to the shaft, a firing driver movable toward the end effector, wherein the electric motor is configured to impart a firing motion to the firing driver, an articulation driver configured to articulate the end effector about the articulation joint, and a rotatable clutch configured to selectively engage the articulation driver to the firing driver to impart the firing motion to the articulation driver.

A shaft assembly for use with a surgical instrument can comprise a shaft, an end effector, an articulation joint connecting the end effector to the shaft, a firing driver movable relative to the end effector, an articulation driver configured to articulate the end effector about the articulation joint, and a longitudinal clutch configured to selectively engage the articulation driver to the firing driver to impart the movement of the firing driver to the articulation driver.

A shaft assembly attachable to a handle of a surgical instrument, the shaft assembly comprising a shaft comprising a connector portion configured to operably connect the shaft to the handle, an end effector, an articulation joint connecting the end effector to the shaft, a firing driver movable relative to the end effector when a firing motion is applied to the firing driver, an articulation driver configured to articulate the end effector about the articulation joint when an articulation motion is applied to the articulation driver, and an articulation lock configured to releasably hold the articulation driver in position, wherein the articulation motion is configured to unlock the articulation lock.

A shaft assembly attachable to a handle of a surgical instrument, the shaft assembly comprising a shaft including, one, a connector portion configured to operably connect the shaft to the handle and, two, a proximal end, an end effector comprising a distal end, an articulation joint connecting the end effector to the shaft, a firing driver movable relative to the end effector by a firing motion, an articulation driver configured to articulate the end effector about the articulation joint when an articulation motion is applied to the articulation driver, and an articulation lock comprising, one, a first one-way lock configured to releasably resist proximal movement of the articulation driver and, two, a second one-way lock configured to releasably resist distal movement of the articulation driver.

A shaft assembly attachable to a handle of a surgical instrument comprising a shaft including, one, a connector portion configured to operably connect the shaft to the handle and, two, a proximal end, an end effector comprising a distal end, an articulation joint connecting the end effector to the shaft, a firing driver movable relative to the end effector by a firing motion, an articulation driver system comprising, one, a proximal articulation driver and, two, a distal articulation driver operably engaged with the end effector, and an articulation lock configured to releasably hold the distal articulation driver in position, wherein the movement of the proximal articulation driver is configured to unlock the articulation lock and drive the distal articulation driver.

A shaft assembly attachable to a handle of a surgical instrument comprising a shaft including, one, a connector portion configured to operably connect the shaft to the handle and, two, a proximal end, an end effector comprising a distal end, an articulation joint connecting the end effector to the shaft, a firing driver movable relative to the end effector by a firing motion, and an articulation driver system comprising, one, a first articulation driver and, two, a second articulation driver operably engaged with the end effector, and an articulation lock configured to releasably hold the second articulation driver in position, wherein an initial movement of the first articulation driver is configured to unlock the second articulation driver and a subsequent movement of the first articulation driver is configured to drive the second articulation driver.

A surgical stapler can comprise a handle, a firing member, and an electric motor. The electric motor can advance the firing member during a first operating state, retract the firing member during a second operating state, and transmit feedback to the handle during a third operating state. Furthermore, the electric motor can comprise a shaft and a resonator mounted on the shaft. The resonator can comprise a body, which can comprise a mounting hole. The mounting hole and the shaft can be coaxial with a central axis of the resonator, and the center of mass of the resonator can be positioned along the central axis. The resonator can also comprises a spring extending from the body, a weight extending from the spring, and a counterweight extending from the body.

A surgical instrument for cutting and stapling tissue can comprise a handle, a firing member extending from the handle, an electric motor positioned in the handle, and an amplifier comprising a center of mass. The electric motor can be configured to operate in a plurality of states and can comprise a motor shaft. Furthermore, the amplifier can be mounted to the motor shaft at the center of mass. The amplifier can rotate in a first direction when the electric motor is in a firing state, and the amplifier can oscillate between the first direction and a second direction when the electric motor is in a feedback state.

A surgical instrument for cutting and stapling tissue can comprise holding means for holding the surgical instrument, a firing member, and motor means for operating in a plurality of operating states. The plurality of operating states can comprise a firing state and a feedback state. The motor means can rotate in a first direction during the firing state and can oscillate between the first direction and a second direction during the feedback state. The surgical instrument can further comprise feedback generating means for generating haptic feedback. The feedback generating means can be mounted to the motor means.

A surgical instrument for cutting and stapling tissue can comprise a handle, a firing member extending from the handle, and an electric motor positioned in the handle. The electric motor can be configured to operate in a plurality of states, and the electric motor can comprise a motor shaft. The surgical instrument can further comprise a resonator comprising a center of mass. The resonator can be mounted to the motor shaft at the center of mass. Furthermore, the resonator can be balanced when the electric motor is in an advancing state, and the resonator can be unbalanced when the electric motor is in a feedback state.

A method for operating a surgical stapler can comprise initiating an initial operating state. A cutting element can be driven distally during the initial operating state. The method can also comprise detecting a threshold condition at the cutting element, communicating the threshold condition to an operator of the surgical stapler, and receiving one of a plurality of inputs from the operator. The plurality of inputs can comprise a first input and a second input. The method can also comprise initiating a secondary operating state in response to the input from the operator. The cutting element can be driven distally in response to the first input and can be retracted proximally in response to the second input.

A method for operating a surgical instrument can comprise initiating an initial surgical function, detecting a clinically-important condition, communicating the clinically-important condition to an operator of the surgical instrument, accepting an input from the operator, and performing a secondary surgical function based on the input from the operator. The secondary surgical function can comprise one of continuing the initial surgical function or initiating a modified surgical function.

A system for controlling a surgical instrument can comprise a motor, and the motor can drive a firing member during a firing stroke. The system can also comprise a controller for controlling the motor, and the controller can be configured to operate in a plurality of operating states during the firing stroke. The plurality of operating states can comprise an advancing state and a retracting state. The system can also comprise a sensor configured to detect a force on the firing member, wherein the sensor and the controller can be in signal communication. The controller can pause the firing stroke when the sensor detects a force on the firing member that exceeds a threshold force. The system can also comprise a plurality of input keys, wherein the input keys and the controller can be in signal communication. The controller can resume the advancing state when a first input key is activated, and the controller can initiate the retracting state when a second input key is activated.

A surgical instrument can comprise a firing member, a motor configured to drive the firing member, and a controller for controlling the motor. The controller can be configured to operate the surgical instrument in a plurality of operating states, and the plurality of operating states can comprise a firing state for driving the firing member and a warned firing state for driving the firing member. The surgical instrument can also comprise means for operating the surgical instrument in the warned firing state.

A surgical instrument can comprise a handle, a shaft extending from the handle, an end effector, and an articulation joint connecting the end effector to the shaft. The surgical instrument can further comprise a firing driver movable relative to the end effector when a firing motion is applied to the firing driver, an articulation driver configured to articulate the end effector about the articulation joint when an articulation motion is applied to the articulation driver, and an articulation lock configured to releasably hold the articulation driver in position, wherein the articulation motion is configured to unlock the articulation lock.

A surgical instrument can comprise at least one drive system configured to generate control motions upon actuation thereof and defining an actuation axis, at least one interchangeable shaft assembly configured to be removably coupled to the at least one drive system in a direction that is substantially transverse to the actuation axis and transmit the control motions from the at least one drive system to a surgical end effector operably coupled to said interchangeable shaft assembly, and a lockout assembly comprising interfacing means for interfacing with the at least one drive system and for preventing actuation of the drive system unless the at least one interchangeable shaft assembly has been operably coupled to the at least one drive system.

A surgical instrument including a shaft assembly can comprise an end effector comprising a surgical staple cartridge and an anvil, wherein one of the anvil and the surgical staple cartridge is movable relative to the other of the anvil and the surgical staple cartridge upon the application of an opening motion and a closing motion. The surgical instrument can further comprise a movable closure shaft assembly configured to apply the opening motion and the closing motion, a shaft attachment frame operably supporting a portion of the movable closure shaft assembly thereon, a frame member configured for removable operable engagement with the shaft attachment frame, a closure drive system operably supported by the frame member and defining an actuation axis, the closure drive system configured for operable engagement with the closure shaft assembly in a direction that is substantially transverse to the actuation axis when the shaft attachment frame is in operable engagement with the frame member, and a lockout assembly interfacing with the closure drive system for preventing actuation of the closure drive system unless the closure shaft assembly is in operable engagement with the closure drive system.

A surgical instrument can comprise an end effector, a shaft extending proximally from the end effector, and an articulation assembly configured to move the end effector relative to the shaft between an unarticulated position, a first range of articulated positions on a first side of the unarticulated position, and a second range of articulated positions on a second side of the unarticulated position, wherein the first side is opposite the second side. The surgical instrument can further comprise a motor, a controller in communication with the motor, a first input configured to transmit a first input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to an articulated position within the first range of articulated positions in response to the first input signal, a second input configured to transmit a second input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to an articulated position within the second range of articulated positions in response to the second input signal and a reset input configured to transmit a reset input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the unarticulated position in response to the reset input signal.

While various details have been set forth in the foregoing description, the various embodiments may be practiced without these specific details. For example, for conciseness and clarity selected aspects have been shown in block diagram form rather than in detail. Some portions of the detailed descriptions provided herein may be presented in terms of instructions that operate on data that is stored in a computer memory. Such descriptions and representations are used by those skilled in the art to describe and convey the substance of their work to others skilled in the art. In general, an algorithm refers to a self-consistent sequence of steps leading to a desired result, where a "step" refers to a manipulation of physical quantities which may, though need not necessarily, take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It is common usage to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like. These and similar terms may be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities.

Unless specifically stated otherwise as apparent from the foregoing discussion, it is appreciated that, throughout the foregoing description, discussions using terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

In a general sense, those skilled in the art will recognize that the various aspects described herein which can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or any combination thereof can be viewed as being composed of various types of "electrical circuitry." Consequently, as used herein "electrical circuitry" includes, but is not limited to, electrical circuitry having at least one discrete electrical circuit, electrical circuitry having at least one integrated circuit, electrical circuitry having at least one application specific integrated circuit, electrical circuitry forming a general purpose computing device configured by a computer program (e.g., a general purpose computer configured by a computer program which at least partially carries out processes and/or devices described herein, or a microprocessor configured by a computer program which at least partially carries out processes and/or devices described herein), electrical circuitry forming a memory device (e.g., forms of random access memory), and/or electrical circuitry forming a communications device (e.g., a modem, communications switch, or optical-electrical equipment). Those having skill in the art will recognize that the subject matter described herein may be implemented in an analog or digital fashion or some combination thereof

The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In one embodiment, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, those skilled in the art will recognize that some aspects of the embodiments disclosed herein, in whole or in part, can be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of skill in the art in light of this disclosure. In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a Compact Disc (CD), a Digital Video Disk (DVD), a digital tape, a computer memory, etc.; and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link (e.g., transmitter, receiver, transmission logic, reception logic, etc.), etc.).

One skilled in the art will recognize that the herein described components (e.g., operations), devices, objects, and the discussion accompanying them are used as examples for the sake of conceptual clarity and that various configuration modifications are contemplated. Consequently, as used herein, the specific exemplars set forth and the accompanying discussion are intended to be representative of their more general classes. In general, use of any specific exemplar is intended to be representative of its class, and the non-inclusion of specific components (e.g., operations), devices, and objects should not be taken limiting.

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations are not expressly set forth herein for sake of clarity.

The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely exemplary, and that in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected," or "operably coupled," to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being "operably couplable," to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components, and/or wirelessly interactable, and/or wirelessly interacting components, and/or logically interacting, and/or logically interactable components.

In some instances, one or more components may be referred to herein as "configured to," "configurable to," "operable/operative to," "adapted/adaptable," "able to," "conformable/conformed to," etc. Those skilled in the art will recognize that "configured to" can generally encompass active-state components and/or inactive-state components and/or standby-state components, unless context requires otherwise.

With respect to the appended claims, those skilled in the art will appreciate that recited operations therein may generally be performed in any order. Also, although various operational flows are presented in a sequence(s), it should be understood that the various operations may be performed in other orders than those which are illustrated, or may be performed concurrently. Examples of such alternate orderings may include overlapping, interleaved, interrupted, reordered, incremental, preparatory, supplemental, simultaneous, reverse, or other variant orderings, unless context dictates otherwise. Furthermore, terms like "responsive to," "related to," or other past-tense adjectives are generally not intended to exclude such variants, unless context dictates otherwise.

Although various embodiments have been described herein, many modifications, variations, substitutions, changes, and equivalents to those embodiments may be implemented and will occur to those skilled in the art. Also, where materials are disclosed for certain components, other materials may be used. It is therefore to be understood that the foregoing description and the appended claims are intended to cover all such modifications and variations as falling within the scope of the disclosed embodiments. The following claims are intended to cover all such modification and variations.

The disclosure of U.S. patent application Ser. No. 12/765,330, entitled SURGICAL STAPLING INSTRUMENT WITH AN ARTICULATABLE END EFFECTOR, which issued on Nov. 13, 2012 as U.S. Pat. No. 8,308,040, is incorporated herein by reference in its entirety. The disclosure of U.S. patent application Ser. No. 13/524,049, entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING A FIRING DRIVE, which issued on Aug. 11, 2015 as U.S. Pat. No. 9,101,358, is incorporated herein by reference in its entirety.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Preferably, the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

In summary, numerous benefits have been described which result from employing the concepts described herein. The foregoing description of the one or more embodiments has been presented for purposes of illustration and description. It is not intended to be exhaustive or limiting to the precise form disclosed. Modifications or variations are possible in light of the above teachings. The one or more embodiments were chosen and described in order to illustrate principles and practical application to thereby enable one of ordinary skill in the art to utilize the various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the claims submitted herewith define the overall scope.

What is claimed is:

**1**. A housing for use with a surgical instrument that includes a shaft and an end effector, wherein the surgical instrument includes an articulation assembly configured to move the end effector relative to the shaft, the housing comprising:

a motor operably supported by the housing;

an articulation drive configured to transmit at least one articulation motion to the articulation assembly to move the end effector between an articulation home state position and an articulated position;

a controller in communication with the motor;

a first input configured to transmit a first input signal to the controller, wherein the controller is configured to activate the motor to generate the at least one articulation motion to move the end effector to the articulated position in response to the first input signal; and

a reset input configured to transmit a reset input signal to the controller, wherein the controller is configured to activate the motor to generate at least one reset motion to move the end effector to the articulation home state position in response to the reset input signal.

**2**. The housing of claim **1**, wherein the housing comprises a portion of a handle.

**3**. The housing of claim **1**, wherein the housing further comprises a second input configured to transmit a second input signal to the controller, wherein the controller is configured to move the end effector in a first direction in response to the first input signal and in a second direction opposite the first direction in response to the second input signal.

**4**. The housing of claim **3**, wherein the reset input signal comprises a simultaneous transmission of the first input signal and the second input signal to the controller.

**5**. The housing of claim **3**, wherein the housing comprises a rocker switch which includes the first input, the second input, and the reset input.

**6**. The housing of claim **1**, wherein the articulation home state position comprises positioning the end effector in longitudinal alignment with the shaft.

**7**. The housing of claim **1**, wherein the housing is removably coupleable to the shaft.

**8**. A surgical instrument, comprising:

an end effector;

a shaft extending proximally from the end effector;

an articulation assembly configured to move the end effector relative to the shaft between an unarticulated position, a first articulated position on a first side of the unarticulated position, and a second articulated position on a second side of the unarticulated position, wherein the first side is opposite the second side;

a motor;

a controller in communication with the motor;

a first input configured to transmit a first input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the first articulated position in response to the first input signal;

a second input configured to transmit a second input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the second articulated position in response to the second input signal; and

a reset input configured to transmit a reset input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the unarticulated position in response to the reset input signal.

**9**. The surgical instrument of claim **8**, wherein the unarticulated position comprises positioning the end effector in longitudinal alignment with the shaft.

**10**. The surgical instrument of claim **8**, further comprising a handle.

**11**. The surgical instrument of claim **10**, wherein the handle is removably coupleable to the shaft.

**12**. A surgical instrument, comprising:

an end effector;

a shaft extending proximally from the end effector;

an articulation assembly configured to move the end effector relative to the shaft between an unarticulated position, a first range of articulated positions on a first side of the unarticulated position, and a second range of articulated positions on a second side of the unarticulated position, wherein the first side is opposite the second side;

a motor;

a controller in communication with the motor;

a first input configured to transmit a first input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to an articulated position within the first range of articulated positions in response to the first input signal;

a second input configured to transmit a second input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to an articulated position within the second range of articulated positions in response to the second input signal; and

a reset input configured to transmit a reset input signal to the controller, wherein the controller is configured to activate the motor to move the end effector to the unarticulated position in response to the reset input signal.

**13**. A surgical instrument, comprising:

a shaft;

an end effector extending distally from the shaft, wherein the end effector is configured to articulate relative to the shaft between an unarticulated position and a plurality of articulated positions;

a motor;

a controller;

an articulation input, wherein the controller is configured to activate the motor to move the end effector to an articulated position in response to an actuation of the articulation input; and

a return input, wherein the controller is configured to activate the motor to move the end effector to the unarticulated position in response to an actuation of the return input.

**14**. A surgical instrument assembly, comprising:

a shaft;

an end effector, wherein a portion of the end effector is configured to articulate relative to the shaft between a home position and a plurality of articulated positions;

a motor;

a controller;

an articulation input, wherein the controller is configured to activate the motor and move the articulatable end effector portion in response to an actuation of the articulation input; and

a return input, wherein the controller is configured to activate the motor and move the articulatable end effector portion to the home position in response to an actuation of the return input.

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